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ABSTRACT

This publication examines science and mathematics educational research in India and the question of whether science and mathematics education in that country has been an instrument of social change. Seven areas of research are included: (1) science education; (2) mathematics education; (3) science curriculum; (4) methods of teaching science; (5) instructional materials; (6) evaluation; and (7) science teacher education. Appendices include lists of both science and mathematics education studies at the doctoral and master's level from 1939 to the present. (MH)

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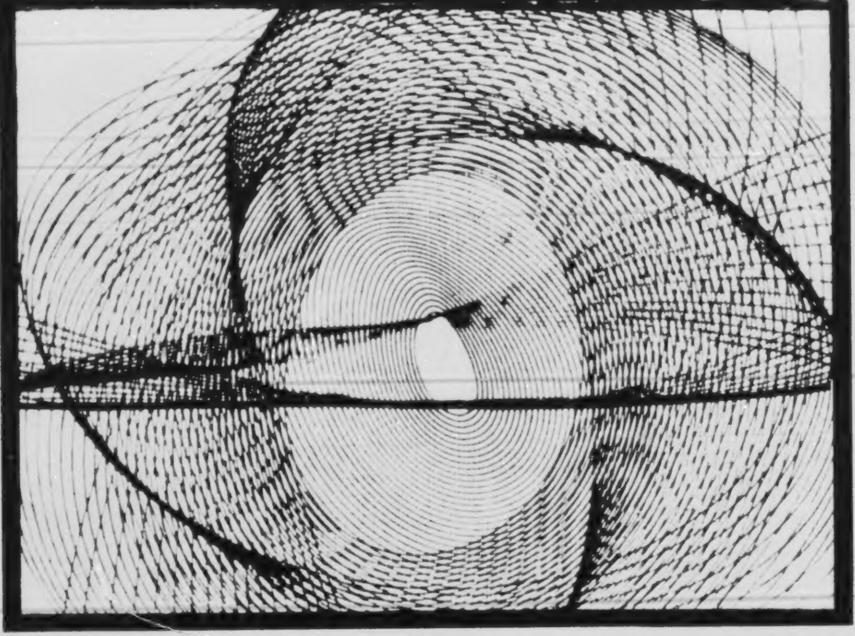

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Research
in
Science & Mathematics Education

Regional College of Education,
Ajmer - INDIA

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Research in
Science & Mathematics Education

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FOREWARD

Never in the history of mankind has there developed greater need and respect for science as in the present age. Traditionally, science was considered to be a subject to be studied in the laboratories where the students were content to juggle with test tubes and in changing the colour of liquids. But, fortunately, science has now moved out of the 'sanctified' laboratories and is having intense ramifications in the various sphere of the lives of men and women. It will be no exaggeration to say that of all the fields of human knowledge, it is science that provides the greatest outlet for creative activity. The achievements of science can be seen in the discoveries and the unifying principles and theories. They are the result of immense resourcefulness in design, flexibility of thought, far reaching imagination and speculation and a combination of reasoning and intuition.

But in our country in the past there has been no recognition of the creativity and vitality of science. There were mounting pressures for information in the classroom and it took away all the flavour of adventure, controversy, open mindedness and creativity. Naturally, the state of research in science education is poor and the true goals of science education are not realized. By teaching science in schools we mean teaching a set of subjects like physics, chemisrry or biology or mathematics in their exclusiveness as if they had no relevance to the emerging needs of a society engaged in a huge task of social change and reconstruction.

Obviously, the whole bases of research in science education has centred round the whole gamut of research in textbooks, instructional materials, methodology of teaching and teaching styles. This observation is fully substantiated by the monograph under review where nearly 600 studies in science and mathematics education have been classified, categorized and their implications adequately discussed.

Research in science education will have to be a continuing process. It will have to keep pace with the age of change. It has to, for science is a way of life. Research in science and mathematics education will assume greater importance with the introduction of science as an integral part in the school curriculum upto class X in the new pattern of ten year schooling. This status survey of the investigations done at masters and doctoral level, I am hopeful, will sensitize science teachers and more particularly science teacher educators and policy makers to set their house in order. If that consummation is achieved the efforts of Professor V.N. Wanchoo, Principal Regional College of Education, Ajmer and his colleagues would have been adequately rewarded.

New Delhi
March 9, 1976

Rais Ahmed

DIRECTOR
National Council of Educational
Research and Training.

PREFACE

Ten years ago the authors of the Education Commission observed that the destiny of India is being shaped in her millions of classrooms. What type of destiny is on the anvil can be revealed by research only. Education as an effective input for nation building, is dependent on a large number of factors, such as, students, teachers, numerous types of materials and facilities, right traditions, an attitude for innovation and inventiveness. In a country, such as India, it should be dominated by a concern for the depressed, the down-trodden and the weak. Science, its tradition, processes, controversies, ever-expanding frontiers, its methods of approach, is at once a hand-maid of educational processes which can, and should be, utilised as an Instrument of social change for betterment of society. Have our courses in Science and Mathematics in schools and colleges, our methods of teaching, the resources available in the country and the human power—teachers and educational administrators in which we abound,—been able to assist the process of change in this country during the last half a century in the desired direction ? What do investigations reveal ? Have investigations been conducted on diverse issues in science education which can tell us where we are and in which direction we are heading. The National Council of Educational Research and Training in collaboration with various universities in our country is trying to address itself to this challenging task. This monograph is also an humble effort in this direction.

This work, in fact, was initiated at the National Council of Educational Research and Training. Mr. H.L. Sharma, Lecturer in Physics. Department of Education in Science and Mathematics, NIE assisted in this project. Data for the survey was collected from various sources, from the universities and from teacher training colleges. It was compiled, analysed and given a shape at New Delhi. The entire material was discussed in a Workshop in the Department of Education, University of Kerala, Trivandrum, under the able guidance of Professor Vedamani N. Manuel. Professor K. K. Pillai, Professor Srinivas Rao, staff members of the Department of Education, University of Kerala and several others from the universities in the south participated in this workshop. The analysed data was categorised under various chapters. An attempt was made to identify gaps in Science and Mathematics Education research.

The whole work was again discussed in a Workshop held at the Khalsa College of Education, Amritsar. The participants hailed from the Universities and the training colleges in the northern region. Professor Rais Ahmed, Director, National Council of Educational Research and Training, Professor A.N. Bose and Professor M. S. Arora, DESM, NIE also participated in it. The participants in this workshop identified, analysed and categorised the problems that needed to be taken up for research in the area of Science and Mathematics Education on a priority basis.

The whole work was reviewed once again by the staff members of the Regional College of Education, Ajmer. Dr. J.K. Sood, Mrs. S. Masih (both currently at RCE, Bhopal), Mr. S.P. Mishra and Dr. G.N. Bhardwaj rendered great help in this direction. The whole work was finally edited by Mr. T.N. Raina, Reader in Education. It is hoped that this work will be continued with greater emphasis on a priority basis in consultation with the University Departments of Education and the Teacher Training Colleges as well as Special Research Centres in the country so that a fruitful dialogue is continued for improvement in the quality of research in this important area of work.

In conclusion thanks are due to all those who helped in the preparation of this monograph and specially to Prof. Rais Ahmed, Director, NCERT, who, in spite of an extremely busy schedule found time to write a scholarly foreward to this publication. Thanks are also due to the participants of Kerala and Amritsar Workshops. Their names and addresses are given in Appendix III.

AJMER
March 31, 1976.

V. N. Wanchoo

PRINCIPAL
Regional College of Education

Research in Science and Mathematics Education
A point of View

Constitutionally speaking, school education is a State responsibility. To this extent school education can be said to be decentralised. In a State, however, it is overcentralised. The State determines the subjects, their number and structure at different school levels such as primary, middle, high and higher secondary. It prescribes syllabuses for all subjects through its agencies, the Directorate of Education and State Board of Examination/Education. It also prescribes textbooks, provides facilities of staff, space, teaching materials and the like and it holds examination at different intervals to determine the progress in studies of each pupil on rolls in a school recognised by it. The structure of a school, the number of teachers required, their qualifications, their teaching load, the school time table and various other connected administrative aspects are also determined by it. A State lays down norms for all the administrative and academic aspects on the basis of tradition, which has been inherited from good old days.

During the last decade or two all these policies are being questioned one after another. The reasons are not far to seek. The Reports of two Education Commissions headed by Dr. Mudaliar and Dr. Kothari, policies and programmes enunciated and evolved by the NCERT, work done by State Institutes of Education and Science, impact of policies pursued in developed countries and a host of materials prepared by their specialised agencies on scientific lines based on adequate research and publicised in this country have compelled us to have a second look at our policies and materials. The explosion of knowledge and techniques, vexing problems of agriculture, industry, employment, rising population and prices, etc. makes us think whether education at the school and college levels is worthwhile, meeting the needs of an individual and the nation. The energy crisis is giving this problem a shot in the arm. Several books written recently, such as Deschooling Society, have compelled communities in the West also to sit back and assess the result of spending tax payers money on policies and programmes which are no longer considered to be justified. "Learning to Be" a report of a Commission set up by Unesco, focuses on the growing and disturbing problems of school education in both developed and developing countries.

Whereas the world of education in developed countries is also in turmoil this is more true of developing countries, particularly India, in which the rate of population growth out-strips rate of economic growth. The facilities for better education for an ever increasing population are becoming scarce. The education component of the Fifth Five Year Plan is in doldrums. Too few rupees chase too many people. What should be done to solve this problem ? Several solutions may be offered to this broad question which we may not discuss at present. One solution which may straightway be offered is to base our policies and programmes on findings of properly conducted investigations and studies so that these are not based on somebody's opinions, however highly placed he may be in the administrative ladder of State education department.

When an oil refinery is proposed to be set up in a State, or an atomic power plant is established in a particular town, a feasibility study is usually conducted to investigate the viability of the project. But when syllabuses are revised in a State after a period of five or more years, which affect the studies of millions of children, a small committee of school administrators does this job without consulting research findings in this area. In many areas of education, as this paper will show later on, findings are not available because research is lacking. The temples of education in the universities have not broadened their horizons and do not keep pace with the demands of the time.

Whatever research is conducted in the problems concerning school education in general and science education in particular in the university departments of education and teacher training colleges does not get the publicity that is required. A strong and a wide communication gap exists not only between research centres but also within a centre.

Research conducted in Physics, Chemistry, Botany, Zoology, Mathematics or any other discipline in Science gets published in respective research journals in India and abroad. The standard of the investigations and useful ness is sometimes determined by the Research Journal which publishes it. Nature, Journal of Physical Society, Journal of Chemical Society, Journal of Chemical Physics, and the like are well known which publish investigations in their respective disciplines. No such journal exists in India for research in Science and Mathematics Education. Consequently, good work done in various centres neither reaches the consumer nor the investigator. Some investigations get published in foreign journals but most workers and consumers in India remain unaware of it.

Because investigations do not get published, much cannot be said about their standard. Many investigations conducted at the M. Ed. level look more as essays than research studies. There is a tremendous duplication of studies in the same area and sometimes the same problem such as construction of a standardised test in a particular subject for a particular class. Questionnaire and questionnaire-cum-interview are the two techniques usually used at the M. Ed. and even at Ph. D. levels. Other techniques, which may be more reliable are, perhaps, not known and, therefore, not used. Education is a social science and many reliable techniques, perhaps, have not been evolved so far. The whole field is open to be explored and exploited. There are several areas in scientific research in which India has made significant contribution in the past. Scattering of Light is one such area worthy to mention. No such significant contribution has been made by India in developing research in science education. In fact this area is in its infancy. It is beset with teething troubles and deserves to be nourished and nurtured.

School education is a multi-dimensional system. It depends on a large number of factors which impinge on each other. Each factor has its own growth rate and level, operating under several constraints in this country.

Dimensions may be listed as follows :

1. Students
2. Teachers

3. Facilities
4. Academic set up, and
5. Administrative set up.

The factors that affect are many and it may be difficult to prepare an exhaustive list. Moreover, these factors vary from one State to another, from one school to another, from one environment to another, in the same school from one class to another and in the same class from one pupil to another. The net-work of factors is indeed very complex. It makes Education a very complex enterprise.

Let us take up one dimension as an example. The Student. The factors involved are: age, I. Q., family and socio-economic background, peer group relationship, attitude of community and the family towards education, physical health such as eye-sight, hearing, motor skills, etc., interests, aptitude for science, etc., etc. A class of 50 students may, therefore, appear as a complex web with many factors playing with each other. It may be compared to a situation of a gas within molecules enclosed in a space, each molecule having different characteristics. The class will interact with the teacher, teaching-learning situation, facilities available, learning environment provided, class time-table, what happens in the neighbouring classes, school discipline, supervision policy and a host of other factors. Factors emanating from other dimensions and impinging on each other makes the teaching-learning process very complex. If the aim of educational process is to shape the personality of a child so that he can serve his future needs, contribute to the needs and development of the community and the nation of which he is a part and learn to be an alert learner all his life, then inter-relationships of various dimensions and their factors operating in a class room as well as outside it must be studied adequately. *Hence the need for educational research.*

There has been a tremendous growth in school population after Independence. The number of schools have more than trebled in the last two decades. Since the beginning of the Fourth Five Year Plan considerable attention has been paid towards improvement of the quality of education. State Institutes of Education and Science have been set up in most States. A National Science

Teaching Project has been initiated through the NCERT with some assistance from the UNICEF. Syllabuses in Physics, Chemistry, Biology and Mathematics have been drawn up at lower and upper elementary school levels. Textbooks following these syllabuses have been written, published and made available to schools. Some guide books have also been prepared, equipment kits sent to schools for demonstration of experiments; science teachers have been provided in some States and orientation courses given to existing teachers, evaluation material in science has been prepared in the form of question banks; so much has been done and crores of rupees spent. But none of these steps already taken or more steps planned for future have any research base. University departments of education and teacher training colleges offering instruction at the M. Ed. level have remained more or less aloof from these developments. They have neither offered research assistance nor taken ideas or identified problems for further research. The last mentioned conclusion is obvious from the list of investigations appended in the end of this monograph.

What is worse is that the main problems confronted in the teaching of science in millions of classrooms in the country have remained outside the purview of research centres. Should the concept of acceleration, for example, be introduced in class VII or class IX ? What is the depth to which it should be taught at a given class level ? Can it be taught at a lower level with advantage with the help of some aids, can suitable aids or experiments or experiences be devised for this purpose ? Psychologists claim that any concept, however, abstract can be taught to children at any class level if proper means are employed. Acceleration used to be taught in class IX in many States. Now it has been brought down to class VII. Has this shift in class level been successful ? Do students in class VII understand the concept with the given demonstration equipment and the guide-lines laid down in the Teacher's Guide ? Can a better method be devised for it ? These are questions of fundamental importance which have neither been investigated so far nor, perhaps, answered satisfactorily anywhere. What is true for the concept of acceleration is equally true for all concepts included in the various science subjects at different class levels.

Next in importance are the teaching methods employed for various concepts, principles or facts in science subjects. Should a lesson on 'photosynthesis', for example, start with a film on the subject, a set of slides, an experiment by students, a discussion by a group of students to whom this topic is assigned a couple of days before it is introduced in the class or with an introduction by the class teacher ? What activities should follow, and in which sequence ? Which lesson plan, under given conditions, is of maximum advantage leading to satisfactory student understanding or achievement. Which plan is difficult or easy for a teacher, under given conditions, to conduct in a class ? Which plan takes care of the gifted as well as under-achievers in a class, which takes care of one category only ? Which plan lays due emphasis on developing scientific method-hypothesis, data collection, activities, evaluation ? Which plan is more practical and less theoretical or vice versa ?

A cursory look at the appendix will indicate that very little work has been done in curriculum development and improvement in science and mathematics, the base or foundation of a school system. The questions what to teach, when to teach, how to teach, with which materials to teach and how to evaluate achievement are more or less un-answered as far as science and mathematics are considered, from the modern point of view.

Although pedagogy is a social science, attempts have been made recently, and quite successfully to a large extent, to put curriculum development and its procedures on a sound scientific footing. Reference may be made here to projects such as P.S.S.C., Chem-Study, C.B.A., B.S.C.S., SMSG in USA and Nuffield in U.K. Similar projects in Australia, Scotland and a number of OECD and African countries are worthy of mention. Content outlines prepared for a particular subject at a class level were taken as hypotheses. Materials were prepared by university scientists, method experts and school teachers. The materials were tried out on a sample of school students. The hypothesis was modified with the feed–back. The modified materials and techniques were tried on a very large population. PSSC (Physics) was tried out in about 300 schools. The entire material, from syllabus to examination questions, were again modified on the basis of these trials. The final drafts were published and prepared for wider introduction in schools. These projects led to a large number of studies and investigation and gave a spurt to research activities. The Harvard Project Physics gave rise to and is based on several hundred scientific investigations carried out in and outside Harvard University. Nothing of this kind has happened in India. NCERT Science Teaching Project is opinion-oriented. Whatever work of developmental nature has originated from State Institutes of Science Education, has not given spurt to research in Science Education, it has not even influenced it distantly. The future of science education, therefore, does not appear to be bright in this country. Copying foreign projects may serve our need to a limited extent, it is no substitute for indigenous material developed on scientific lines. Though universities have multiplied in the last two decades, so have research laboratories, yet we have failed to produce a second Raman or a Bhaba because information oriented science and its education, devoid of variety of methods available, devoid of imagination and creativity cannot lead us far.

A large number of new material such as text-books, guide-notes, questions, supplementary readers, equipment kits, films for teachers, films for students, have been prepared under the Nuffield Science Project in U.K. for primary, secondary ordinary level, advanced level, and for integrated science and individual sciences. Most materials emphasise science as series of investigations. Textbooks have not been written for a few subjects in order to make their learning by students completely investigatory. An analysis of the authors and workers who have conceived and designed these projects, prepared materials and evaluated them, indicate that leadership has come from university science and education departments as well as teacher training colleges. The contribution of the latter category is significant in comparison to their counterparts in India in our indigenous efforts. There may be several reasons for this difference, but one reason is obvious. Whereas content and methods of science are given equal weightage in the training colleges and university departments of education in U.K., we almost ignore the content of science and its structure in our training institutions. This leads to an imbalance in all our training programmes at both B. Ed. and M. Ed. levels and it affects adversely the development of science education in the country as well as research in various problems confronted in the area. We emphasise theory to the exclusion of practice in science. Whatever experiments students conduct are confirmatory, not investigatory in nature. It does not lead to the real purpose of teaching science. This is true at all levels—school, college and university.

This may be one of the reasons why some areas of science teaching are ignored by research workers. They are not aware of the problems, their depth, their nature, inter-relationship, complexity and influence. It is the duty of the profession to study this area rather closely, identify some leads, plan multi-pronged activities and pursue decisions with seriousness and zeal.

These and other considerations served the main motivations in the publication of this monograph. Research in Science and Mathematics Education done at various universities has been analyzed and classified which clearly illustrates the attention given to a field and the various aspects within that field. This, we hope, will help the present and the prospective researchers in the field of Science and Mathematics Education to study as to what has been done, what needs to be done more perfectly and what new areas are to be explored and investigated. If that consummation is achieved, the efforts involved in the preparation and publication of this monograph would have been adequately rewarded.

Research in Mathematics Education

Secondary School Mathematics is the basic structure on which the whole superstructure of Mathematics, Physical Sciences, Social Sciences and Technology in the universities and technical institutions rests. Weaknesses in the basic structure have led in the past and can lead in future to considerable weaknesses in the superstructure. It has been realized that Mathematics is the foundation and the vitalising energy for the basic sciences. Mathematical knowledge has been estimated to double in a period of about fifteeen years. More mathematics and more profound mathematics has been created in the world since Independence, than was created by the whole of the mankind till 1947. This tremendous explosion of knowledge will surely have an impact on secondary school mathematics.

During the last fifty years, mathematics has not only developed new concepts but has developed a new meaningful language. It is desirable that this rich language should permeate the secondary school level as soon as possible. Mathematics syllabi were designed to meet the needs of University Mathematics, Physics and Engineering, of fifty years ago. The requirements of the subject have changed and, therefore, a re-thinking on secondary school mathematics has become necessary. Science and technology have undergone tremendous changes during the last fifty years and this requires changes both in the content and spirit of secondary school mathematics syllabi also. These changes must be brought about as soon as possible. Instead of the present manipulational or bag of tricks courses, we have to develop courses which emphasize basic concepts.

The teaching of secondary school mathematics should reflect something of its nature. It must bring out its chief characteristics such as abstractness, precision, generality, logical nature, etc. Mathematics has too long been taught by the rule of thumb method. It has almost been taught as mechanics is taught to an uneducated person in a motor workshop. Certain rules are given to the students very often without proofs or with proofs by intimidation or with proofs by waving of hands or with proofs resting on the authority of the teacher. The students are expected to apply these rules to numerous examples and they have to go on applying these rules till they are completely 'brain washed' and forget their initial objectives of the rules.

The teaching of mathematics at the secondary school stage is so defective that very often a student has to unlearn at the college stage or at the research stage whatever he has learnt at the school stage, since he has not really or correctly learnt it. The unlearning is a painful and difficult process. It is, therefore, necessary that only correct mathematics should be taught correctly at the secondary school stage. The instructional problems of secondary school mathematics have been concerned with ways in which students learn mathematics; methods of teaching mathematics; and the implications of effectual mathematical instruction.

New processes and new points of view in mathematics have provoked a revolution in many countries during the past decade, which have resulted in emphasis now being given to concepts and techniques that could be found only in graduate courses prior to that time. Accordingly, most teachers should expect the point of view of modern mathematics to be an extension of the one developed in their under graduate training. In many cases the new concepts and techniques are easier than the old. However, it is quite essential that one be willing to reorient his thinking if he wishes to appreciate fully the new point of view which so thoroughly permeates modern mathematics.

The significance of modern mathematics as a part of our scientific culture has been established. It represents a way of thinking that should be understood by high school teachers and should underlie the mathematical instruction of junior and senior high-school students. While we shall not be teaching much modern mathematics at the high school level, we can not avoid providing our students with an introduction to mathematics. Will it be the mathematics of 300 B.C. ? Or the mathematics of the 18th century,? Or the mathematics of the 20th Century ? Only research on mathematics education can give answers to these questions.

Research bearing on Mathematics education in our country is neither sufficient in quantity nor commendable for quality. The bulk of the work falls into the category of studies which bear only indirectly on the methods of teaching. There have been a total of 335 studies in Mathematics Education at the M. Ed. and Ph. D. levels in all the Indian Universities from 1939 to 1966. This number also includes the studies completed in Rajasthan and Kerala Universities upto 1973. The number of studies conducted at the Ph. D. level is only two.

TABLE 1

Classification of Research Studies in Mathematics Education

(1939–1966)

S.No.	Area	No. and percentage of studies	
1.	Achievement.	117 (35.00)	
	(i) Construction of Achievement Tests		114 (97.44)
	(ii) Interdisciplinary Achievement		3 (2.56)
2.	Diagnosis.	56 (16.71)	
	(i) Diagnostic Tests		23 (41.07)
	(ii) Errors in Mathematics		17 (30.36)
	(iii) Difficulties in Mathematics		16 (28.57)
3.	Mathematics Teaching	35 (10.44)	
	(i) Methods of Teaching		30 (85.72)
	(ii) Problem-solving		1 (2.86)
	(iii) Concept Formation		4 (11.42)
4.	Evaluation.	27 (8.06)	
	(i) Causes of Backwardness		15 (55.55)
	(ii) Causes of Failures		5 (18.52)
	(iii) Evaluation		7 (25.93)
5.	Curriculum.	24 (7.16)	
	(i) Correlation in Mathematics		9 (37.50)
	(ii) Curriculum Studies		15 (62.50)

S.No.	Area	No. and percentage of studies	
6.	Mathematical Understanding.	21 (6.26)	
	(i) Mathematical Ability		20 (95.24)
	(ii) Test of Understanding		1 (4.76)
7.	Teaching aids.	18 (5.37)	
	(i) Textbooks		12 (66.66)
	(ii) Teaching Aids		6 (33.33)
8.	Attitude, Achievment and Socio-Economic Status.	17 (5.07)	
	(i) Attitude towards Mathematics		12 (70.59)
	(ii) Relationship between Attitude, Achievement and Socio-Economic Status		5 (29.41)
9.	Interest, Intelligence and Achievement.	11 (3.28)	
	(i) Relationship between Interest, Achievement and Intelligence		5 (45.45)
	(ii) Interest towards Mathematics		6 (54.54)
10.	Professional Preparation of Mathematics Teachers.	4 (1.2)	
	(i) Professional Preparation		3 (75.00)
	(ii) Mathematics Teacher		1 (25.00)
11.	Status of Mathematics	2 (0.60)	
12.	Cheating	1 (0.30)	
13.	Functional Thinking	1 (0.30)	
14.	Contribution of Indian Mathematics	1 (0.30)	
	Total	335 (100.00)	

Research at M. Ed. level has been done in various areas. 117 (35.00 per cent) studies, have been conducted in the area of Achievement. Out of this total 114 (97.44 per cent) studies are in the field of construction of Achievement Tests, while 3 (2.56 per cent) studies are in the field of Interdisciplinary Achievement, where achievement in Mathematics has been compared with the achievement in other subjects.

In the area of Diagnosis a total number of 56 (16.71 per cent) studies have been conducted. Out of this total, diagnostic tests have been constructed in 23 (41.07 per cent) studies. The Errors in Mathematics have been studied in 17 (30. 36 per cent) studies while the difficulties in Mathematics have been studied in 76 (28.57 per cent) studies.

The next area is Mathematics teaching where a total number of 35 (10. 44 per cent) studies have been completed. Out of this total, a good number of studies i. e., 30 (85. 72 per cent) have been done in the Methods and Teaching of Mathematics. Only 1 (2.86 per cent) study has been done in the area of Problem Solving while 4 (11.42 per cent) studies have been done on concept formation in Mathematics.

27 (8.06 per cent) studies are conerned with investigations into the causes of Backwardness, Causes of Failures and Evaluation. 15 (55.55 per cent) studies have been done in the area of Backwardness while 5 (or 18.52 per cent) studies have been completed in the area of causes of failures. 8 (25.93 per cent) studies have been completed in the area of Evaluation.

In the area of Curriculum, 24 (7.16 per cent) studies have been conducted. 9 (37.50 per cent) studies are related to the Correlation of Mathematics while the remaining 15 (62.5 per cent) studies are Curriculum studies in Mathematics.

The next field is Mathematical Understanding where a total number of 21 (6.26 per cent) studies have been conducted which include 20 (95.24 per cent) in the area of Mathematical Ability and 1 (4.76 percent) in Construction of Test of Understanding.

18 (5.37 per cent) studies have been completed in Text Books and Teaching Aids. In the former area i. e., Text books 12 (66.66 per cent) investigations have been done, while in the area of Teaching Aids 6(33.33 per cent) studies have been conducted.

In the field of relationship between Attitude, Achievement and Socio-Economic Status and Attitude towards Mathematics, in all 17(5.07 per cent) studies have been carried out. 12 (70.59 per cent) studies are on Attitude towards Mathematics and 5 (29.41 per cent) are on the Relationship between Attitude, Achievement and Socio-Economic Status.

The next area is that of Interest, Intelligence and Achievement where 11 (3.28 per cent) studies have been completed. In 5 (45.45 per cent) studies a relationship between Interest, Achievement and Intelligence has been investigated while in 6 (54.54 per cent) studies the Interest towards Mathematics has been studied.

In the field of Professional Preparation of Mathematics Teachers, in all 4 (1.2 per cent) studies have been carried out. There are certain other fields where the number of studies carried out is very small. These fields are Status of Mathematics with 2 (0.60 per cent) studies, cheating with one study and Functional Thinking and Contribution of Indian Mathematics with one (.30 per cent) study each.

TABLE 2

University Wise Classification of Research Studies in Mathematics Education (1939--1966)

Name of the University	No. of Studies	Precentage of Studies	Rank
Madras University	44	13.13	1
Bombay University	34	10.15	2
Delhi University	28	08.35	3
Baroda University	26	07.76	4
Osmania University	23	06.86	5
Allahabad University	19	05.67	6
Saugar University	18	05.37	7
Lucknow University	16	04.77	8
Kerala University	15*	04.47	9
Nagpur University	14	04.18	10

Name of the University	No. of Studies	Precentage of Studies	Rank
Patna University	13	03.88	11
Rajasthan University	10*	02.98	12.5
Andhra Pradesh University	10	02.98	12.5
Sardar Patel University	09	2.68	14.5
Punjab University	09	02.68	14.5
Gujarat University	09	02.38	16
Agra University	07	02.08	17
Jabalpur University	05	01.50	18.5
Utkal University	05	01.50	18.5
Gorakhpur University	04	01.20	21
Aligarh University	04	01.20	21
Vikram University	04	01.20	21
Mysore University	02	00.60	23
Bihar University	01	00.30	27.5
Banaras University	01	00.30	27.5
Calcutta University	01	00.30	27.5
Visva Bharti University	01	00.30	27.5
Jamia Milia Islamia University	01	00.30	27.5
Kurukshetra University	01	00.30	27.5
Punjabi University	01	00.30	27.5
S. N. D. T. University	01	00.30	27.5
Total	335	100.00	--

Research studies in the field of Mathematics Education have been taken up by 31 Universities in India during the period 1939 to 1966. The number (31) looks promising but when we analyse the studies we find that in only 11 universities the number of studies in the area of Mathematics Education is above 10. The highest number 44 (13.13 per cent) is from Madras University, which tops the list. The second rank has been obtained by Bombay University with 34 (10.15 per cent) studies to its credit. The next rank has been obtained by Delhi University with 28 (8.35 per cent) studies. It is followed by Baroda University with 26 (7.76 per cent) studies, Osmania University with 23 (6.86 per cent) studies and Allahabad University with 19 (5.67 per cent) studies. The next three ranks are held by Saugar, Lucknow and Kerala Universities with 18 (5.37 per cent), 16 (4.77 per cent) and 15 (4.17 per cent) studies, respectively. The number of studies in the Kerala University also includes studies conducted up to 1973.

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*In these Universities the research studies conducted at the M. Ed. level up to 1973 have also been included.

In Nagpur University only 14 (4.18 per cent) studies have been conducted while in Patna University 13 (3.88 per cent) studies have been conducted. An equal number of 10 (2.98 per cent) studies have been conducted in Rajasthan University and Andhra Pradesh University, but this number (10) in Rajasthan University also includes the studies conducted during the period 1967 to 1973. Sardar Patel and Panjab Universities come next with 9 (2.68 per cent) studies each to their credit. 8(2.38 per cent) studies and 7 (2.08 per cent) studies have been conducted in Gujarat and Agra Universities, respectively. The 7 studies in Agra University also include the two studies conducted at the Ph. D. level. Jabalpur and Utkal universities come next with 5 (1.5 per cent) studies each to their credit which are followed by Gorakhpur, Aligarh and Vikram universities with 4 (1.2 per cent) studies each to their credit.

A rank of 23 has been occupied by Mysore University with only 2 (0.6 per cent) studies. The remaining 8 Universities from the total of 31 have only 1 (0.3 per cent) study each to their credit. The names of these universities are Bihar, Banaras, Vishva Bharti, Calcutta, Jamia Milia Islamia, Khrukshetra, Punjabi and S.N.D.T.

One of the requirements of the M. Ed. degree in the Indian universities is the submission of a report or a dissertation as part fulfilment of the degree. Studies conducted by the students of M. Ed. having mathematics background have been classified in various areas such as Achievement, Diagnosis, Mathematics Teaching, Backwardness, Failure and Evaluation, Curriculum, Mathematical Understanding, Textbooks and Teaching Aids, Attitude, Achievement, Socio-Economic status and Attitude towards Mathematics, Interest Intelligence and Achievement, Professional Preparation, Status of Mathematics, Functional Thinking and Contribution of Indian Mathematics.

Barring two Ph. D. theses, research studies conducted at the M. Ed. level alone are available. The investigations mostly bear on common problems in the field of Mathematics Education. Some of these studies often end with the enumeration of errors or the causes or various difficulties without proceeding to arrive at any perceptive conclusions or suggestions touching on the basic reasons. Very few experimental studies have been carried out. These are mostly of the action research type and cannot be considered a significant contribution to the theory of teaching mathematics. As the context of mathematics is universal, unlike that of some other subjects, duplication of research could have been avoided but, unfortunately, most of the research scholars in one university are unaware of research developments in other universities in the country. Attempts to integrate findings are, therefore, rare and no studies can be traced which try to test the conclusions of earlier works. Many of the studies constitute random attempts and adopt a fragmentary approach to the problem of teaching Mathematics.

Gaps and Neglected Areas

It seems that the significant facts which we have considered do not appear to have influenced research in Mathematics Education in the Indian Universities to an appreciable extent. This is evident from the analysis of problems investigated in the Indian Universities for the last few years. This analysis leads to the following conclusions :

1. The quantum of research in mathematics education in general and that at the Primary level in particular, is very meagre. However, in recent years, comparatively a greater interest seems to prevail over research in problems of Mathematics Education at the primary level.

2. The quantum of research in the area of testing is comparatively large but in areas such as history of mathematics, professional preparation of teachers, and development of mathematical concepts is negligible. Undoubtedly,

testing is an important area but too much importance given to it seems to have adversely affected research in other sectors.

3. The quantum of experimental studies in almost all areas of research, such as curriculum, methods and techniques of teaching, preparation and use of instructional materials including textbooks and teaching aids, psychological aspects of learning mathematics, and so on, are practically negligible. Except one study in the area of methods and techniques of teaching all others belong to normative type.

4. Research in areas as programmed instruction, mass media communication etc., have not come under the purview of research at all.

5. Although behavioural problems in mathematics classes are quite common, only one study, 'Cheating in Mathematics Classes' has been taken up.

Thus research in Mathematics Education is vitiated by several ills. Very few people realise the need for research in this area but this does not prove that our researchers are incapable to do research in Mathematics Education.

Suggestions for Improvement

A special effort has to be made in future to carry out rigorously designed research work in mathematics, and care should be taken to avoid duplication of work. It is imperative to determine the effectiveness of various teaching methods which are practised at present and to ascertain their applicability according to individual differences in pupils. New methods are required to be tried out in all the areas. Research work pinpointed on specific topics rather than 'general' should become the pattern.

In the light of the above observations, a few suggestions for improving the existing conditions are offered:

1. Research in mathematics education at the secondary and primary level should be developed.

2. Research in the following areas may be conducted with particular reference to mathematics education :

(a) Analysis of instructional processes

(b) Techniques for effective instruction

(c) Supervision of instruction, and

(d) Training (Pre-service and In-service) for teachers at both levels.

3. As research should stimulate and cause innovations, greater proportion of studies of experimental type may be conducted atleast for a few years to come. In this context, the following areas of research are suggested:

(a) Development of syllabus including topics from modern mathematics, both for primary and secondary levels

(b) Preparation and use of instructional materials, work-books, hand-books, text-books and teaching aids

(c) Preparation and use of programmed materials

(d) Effective use of mass-media communication

(e) Development of mathematical concepts, and

(f) Effective teaching of Mathematics.

Needed Research

A committee on Mathematics Education headed by Arora (1975) has suggested various fields in mathematics education where the research scholars at the Ph. D. and M. Ed. levels may work.

Specifically, the areas of Mathematics Education, which may be taken up for investigation and research are :

1. Aims and objectives of Mathematics and Mathematics Education-Role of mathematics
2. Learning experiences of the pupils at various stages of Education
3. Processes and techniques of teaching of mathematics
4. (a) Professional preparation of teachers
   (b) Dissemination of information, and
5. Procedures and problems of evaluation of various facts of mathematics education at micro and macro levels and their follow-up.

The over all objective of mathematics education is to improve the quality of education in mathematics in the country.

A list (partial) of problems in mathematics education is given below :

1. Determination of objectives of teaching mathematics at :

   (a) Primary (b) Middle (c) Secondary, (d) Higher Secondary (e) College and (f) University levels, in Indias.

2. Spelling out the social, cultural and economic factors that influence the determining of the programmes in mathematics
3. A study of interdisciplinary give and take of mathematics
4. Researches into history of mathematics with particular reference to India and its interjection into high school and college curriculum
5. A study of principles of learning and their applications to mathematics. Comparison of their efficacies
6. Identification and a comparative study of non-cognitive variables (interest, motivation, confidence, fear) effecting learning of mathematics
7. Gradation of concepts and curriculum design in mathematics
8. Study of (a) Syllabi, (b) Textbooks (c) Multi-media aids pertaining to learning situations in mathematics
9. Determination of various strategies or methods of teaching and a comparative study of their effectiveness
10. A comparative study of curricula of mathematics at various stages in different countries
11. Case study of mathematics classroom
12. (a) Skills and competencies especially required in mathematics teaching

    (b) Objectives of teacher training-extension service; pre-service; in-service.

    (c) Critical study of syllabuses and curricula

    (d) Effective supervision of mathematics teaching programmes

(e) Role of teacher associations in developing professionalism among teachers

13. (a) Role of research in mathematics
    (b) Review of existing research
    (c) Finding out new avenues of research
    (d) Problems of dissemination of research
    (e) Consumer reception of research
    (f) Comprehensive bibliography of journals of mathematics education and research in mathematics education
    (g) Study of innovative programmes in mathematics

14. Critical over-view of the examination system in mathematics at all levels and its impact on methods of teaching

15. Content of question papers-a critical study

16. Evaluation of all of the above steps.

17. Construction of tests : criteria based tests, cognitive tests, etc.

18. Examination of standard achievement tests, especially the tests prepared by N.C.E.R.T.

19. Study of feed back : How evaluation brings-in changes into objectives itself ?

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Research In Science Curriculum

In the last two decades in India, many attempts have been made to improve school curricula in general and science curricula in particular. The agencies that have made attempts in this direction are functioning both at the Central level as well as the state level. At the national level the National Council of Educational Research and Training, and the All India Science Teachers Association have attempted to devise new curricula. At the state level, the Boards of Secondary Education and State Institutes of Education did pioneering efforts to improve science curricula. These agencies worked in three directions to improve the curricula. First the new syllabi was prepared, second text books were written, and thirdly, some states attempted re-training of the school teachers in the light of new curricular demands. There are many questions concerning science curriculum, which are to be answered for bringing about an effective impact on the students. The researches conducted in this field may help in giving some guide lines for this purpose.

Ghosh and Gupta (1968) writing in *The Third Indian Year Book of Education* record that educational research has developed in India only recently and whatever researches have been done since 1939, curriculum is a very neglected area. Curriculum development cannot be studied in isolation from other educational endeavours. The efforts made in other countries for the development of curricula are also related to the Indian situation. Therefore, a gestalt view will help in developing new programmes.

It is evident that since 1956, the beginning of the Physical Science Study Committee Project, U.S.A. many educational changes took place through curricular programmes. The last two decades are characterized by giving (1) advanced level subject matter at earlier ages and grade levels; (2) contributions of university scholars as principal agents in reformulating the content and processes of instruction in each of the major disciplines at both the primary and secondary levels, (3) efforts to apply the mode of inquiry in teaching; and (4) reorganizing content on conceptual schemes that presumably comprise the structure of knowledge within each discipline.

The above mentioned changes are being reflected in curricular materials developed in the western countries. In Indian situations much remains to be done. The efforts made after Independence need further improvement to bring fundamental changes in the existing curriculum. This demand is evident from the following observations :

The *Report of the Education Commission* (1964-66) records that, "against the background of the striking curricular developments that are taking place abroad, the school curriculum in India will be found to be very narrowly conceived and largely out-of-date. Education is a three-fold process of imparting knowledge, developing skills and inculcating proper interests, attitudes and values. Our schools are mostly concerned with the first part of the process-the imparting of knowledge and carry out even this in an unsatisfactory way."

Similarly, Desai and Roy (1974) writing in *A Survey of Research in Education* mention "against the background of curriculum developments in the advanced countries, in India it is narrowly conceived, therefore, it is urgently needed that fundamental research should be executed to provide empirical foundations for curricular change."

It will not be out of place to say that many times curriculum is based upon a narrowly conceived definition, which directs the teaching methodology and instructional material needed for teaching. It needs a drastic change. The definition given in the *Report of the Secondary Education Commission (1952-53)* seems to be most appropriate for bringing this change. It has been defined "as the totality of experiences that pupils receive through the manifold activities that go on in the school, in the classroom, library, laboratory, workshop, playgrounds and in numerous informal contacts between teachers and pupils."

Most of the curricular projects in India lack research support. But the National Council of Educational Research and Training has given some impetus in this direction through the preparation of text books, teaching aids, supplementary material and the new evaluation procedures. A prestegious effort was made in the field of science curricula for the middle classes. In this effort UNESCO through UNICEF helped a lot. A new scheme for primary curriculum in science was developed by the National Council of Educational Research and Training, which was accepted by many states in the country. It is easy to generalize that the efforts made by the NCERT have created conducive climate for the development of new curricula.

The area of crriculum development can be divided into many sub-areas for the purposes of research. The sub-areas are :

1. Place of Science in the School Curriculum
2. Historical Development of Science Curriculum
3. Development of Curriculum
4. Scope and Organization of Science Concepts in Planning the Curriculum
5. Trends in Science Curriculum
6. Science Curriculum Enrichment Programmes
7. Curriculum Evaluation :
    (a) Formative Evaluation
    (b) Summative Evaluation.

In India research in science curriculum did not encompass all the above mentioned sub-areas. Only M. Ed. and Ph. D. scholars have attempted some studies in covering limited sub-areas. The researches available so far fall in the following sub-areas :

1. Place of science in school curricula
2. Historical studies on science curriculum development
3. Development of syllabus or criteria needed for the development of syllabus

4. Scope of science syllabus
5. Recent trends in science curriculum
6. Science curriculum enrichment programmes.

Actual Position

Nearly 404 studies have been conducted in the field of science education at the Ph.D. and M.Ed. level in the various universities of this country. There are only 36 studies, that is only 9 per cent have been attempted in the area of science curriculum.

TABLE I

Classification of Studies on Science Curriculum Research

(Area-wise)

Sub-areas	Frequency	Rank	Percentage
1. Development of Syllabus or Criteria needed for the Development of Syllabus	18	1	50.0
2. Scope of the Science Syllabus	13	2	36.1
3. Place of Science in the School Curricula.	2	3	5.5
4. Historical Studies on Science Curriculum Development	1	5	2.8
5. Recent Trends in Science Curriculum	1	5	2.8
6. Science Curriculum Enrichment Programmes.	1	5	2.8
	36		100.0

TABLE 2

Classification of Studies on Science Curriculum Research

(University-wise)

	University	No. of studies							Rank	Percentage
		I	II	III	IV	V	VI	Total		
1.	Bombay	6	1	—	2	—	—	9	1	25.0
2.	Delhi	4	—	1	1	—	1	7	2	19.5
3.	Allahabad	1	—	—	4	—	—	5	3	14.8
4.	Madras	1	—	—	2	—	—	3	4	7.9
5.	Osmania	—	—	1	1	—	—	2	6.5	5.5
6.	Sagar	2	—	—	—	—	—	2	6.5	5.5
7.	Gujrat	1	—	—	1	—	—	2	6.5	5.5
8.	Kerala	1	—	—	1	—	—	2	6.5	5.5
9.	Sardar Patel	1	—	—	—	—	—	1	10.5	2.7
10.	Vikram	1	—	—	—	—	—	1	10.5	2.7
11.	Rajasthan	—	—	—	1	—	—	1	10.5	2.7
12.	Mysore	—	—	—	—	1	—	1	10.5	2.7
		18	1	2	13	1	1	36		100.0

In this area, there are many sub-areas and for the sake of classification the following sub-areas haves been selected :

I. Place of science in the school curriculum
II. Historical studies on science curriculum-development
III. Development of syllabus or criteria for the development of syllabus
IV. Scope of science syllabus
V. Trends in science curriculum
VI. Science curriculum enrichment programmes.

The first place in the rank order (Table 1) has been secured by the sub-area "Development of syllabus or criteria for syllabus development". The total number of such studies is 18 which is 50.00 per cent of the total number of studies in the field of curriculum.

The second place goes to the "Scope of the science syllabus". This sub-area also covers such studies as examination of syllabus; reactions of teachers towards syllabus etc. The total number of such studies was 13 which is 36.1 per cent of the total number of studies.

The other four sub-areas (as given in the Table) of science curriculum did not attract the attention of the researchers; "Place of science in the school curriculum" was attempted by two researchers out of the thirty six studies. It covers 5.5. per cent of the total number of studies in this area. "Historical studies on science curriculum development", "Trends in science curriculum", and "Science curriculum enrichment programmes," included one study each. All these sub-areas covered 2.8 per cent only of the total number of the studies.

These studies in the field of science curriculum have been attempted in twelve Indian universities. The maximum number of studies, that is, nine were conducted by Bombay University and next to it is Delhi University (seven studies) followed by Allahbad university (five studies). Other universities conducted from one to three studies only. The attempt is not significant.

The above mentioned studies cover one Ph. D. work, entitled "A Tentative Course of Study in General Science for the S.S.C. Examination" and the remaining are M.Ed. dissertations. It has been observed that most of the studies lack a theoretical base and a rationale was not available for the development or evaluation of science curricula. Researchers used the instruments prepared by themselves. The reliability and the validity of the instruments is not known to this reviewer.

Curriculum Trends

The development of the curricular programmes in science can be divided into three phases. Since 1956 the beginning of the Physical Science Study

Committee Project, many Secondary School curricular projects were initiated in U.S.A. Most popular among these projects were ;

(i) Physical Science Study Committee Project, 1956
(ii) Chemical Bond Approach, 1959
(iii) Chemical Education Material Study Project, 1960
(iv) Biological Science Curriculum Study, 1959
(v) Earth Science Curriculum Project, 1963
(vi) Harvard Project Physics, 1964.

These curricular projects influenced the Elementary School Science resulting thereby the beginning of the Elementary School Science Projects. In the second phase of the development of the science curricular projects, for elementary schools, the following projects were started in USA :

(i) Elementary Science Study, 1960
(ii) Science : A Process Approach, 1962
(iii) Conceptually Oriented Programme in Elementary Science, 1965
(iv) Science Curriculum Improvement Study, 1962.

In the third phase, the emphasis was laid upon consolidation rather than expansion. These projects subscribed to the significance of the nature of the discipline and processes of science. The efforts included text books, supplementary reading material and films etc. They used formative as well as summative evaluation for determining the efficacy of the material.

These materials influenced the teaching of science at all levels in most countries. Some nations developed their own material. The Nuffield Science Teaching Projecet in U. K. is one of them. These efforts led to the four curriculum problems highlighted by Connely (1969). These are the problems of :

1. Determining goals
2. Selecting content
3. Organizing content
4. Evaluating curricula.

These four problems do not include all possible curricular problems but it becomes sufficiently comprehensive if we add to this list the problems related to teachers and teaching.

Needed Research

A brief list of the suggestive problems in the science curriculum development is as follows :

1. How are the aims of education related to the planning of science curriculum ?
2. What are the suitable and effective methods of organising science curricula ?
3. Is formative evaluatian needed ?
4. What are the effects of existing curricula on the development of :
   (a) understanding of the nature of science
   (b) interest in science
   (c) process of science
   (d) attitudes towards science.
5. How much emphasis is given on the development of effective abilities ?
6. What is the effect of science curriculum in the development of problem solving skills in different grades ?
7. What is the place of history and philosophy of science in science curricula ?
8. What is the relationship of specific scientific concepts and the developmental stages of children ?
9. How are concepts formed among the children of different grades ?
10. What is the role of summative evaluation in the improvement of science curricula ?
11. How best to determine the efficacy of science curricula through summative evaluation ?

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Research in Methods of Teaching Science

In a period of science and technology dominance, new methods of teaching are emerging with a rapid pace. The word 'method' has a Latin origin which means 'mode' or 'way'. For educational purposes the word 'method' implies communication of knowledge to the learner. It also includes acquisition of knowledge and skills on the part of the learner. Wallen and Travers in the *Handbook of Research on Teaching (Gage, 1963)* have mentioned that the research on teaching methods is the study of consistencies in the behaviour of teachers and the effect of these consistencies on the learning processes. For example, teachers differ from one another to the extent to which they allow students to choose classroom activities, and the extent to which they emit information, and in the emphasis they place on grades.

In this country some studies have been attempted in this field. Inspite of this, methods of teaching are based either on the philosophical traditions or on the personal needs of the teacher. Little has been done to design teaching methods in terms of established principles of learning.

In advanced countries, some efforts have been made to relate teaching methods with principles of learning. This has happened only in the last three decades when Skinner and others started taking an interest in teaching methods.

Beginning from Socrates, over the years a number of teaching methods have evolved. It can be assumed that the Socratic method and the Montessori method are related to the principles of learning. Still it is to be established that their use in the classrooms reflect direct relationship between teaching and principles of learning. The use of educational technology has given a new dimension to teaching methods which incorporate principles of learning on the one hand and the use of mechanical devices on the other.

Over the years a number of teaching methods have been evolved by the teachers. Among the most popular methods are the recitation method, the lecture method, the discussion method and the project method. Since Skinner's (1954) contributions, Programmed Learning, Computer-Assisted Learning and use of Teaching Machines have gained currency. The use of Team Teaching is also gaining popularity in some parts of the world. Micro-teaching is a recent welcome addition to the existing list of teaching methods.

The use of teaching methods differs from one teacher to another but for the sake of systematic study, all teaching methods can, by and large, be grouped as follows :

1. Oral Methods

(a) Talk
(b) Narration
(c) Lecture
(d) Discussion.

2. Observation Methods

(a) Demonstration
(b) Lecture-cum-demonstration.

3. Practical Methods

(a) Experimentation
(b) Laboratory work
(c) Activity
(d) Project
(e) Discovery Learning or Inquiry Approach/Heuristic/Problem Solving.

4. Methods Based on Technical Aids and Miscellaneous

(a) Teaching through Television
(b) Teaching through Teaching Machines
(c) Programmed Learning
(d) Team Teaching
(e) Micro-teaching.

In this paper, the above mentioned general classification of teaching methods has been made as follows :

1. Lecture and demonstration methods
2. Discovery/Experimentation/Laboratory work/Project method/Problem solving method/Heuristic method
3. Methods based on the use of mechanical devices
4. A combination of two methods, or, a comparision between two methods.

N. R. Pillai in the *Third Indian Year Book of Education* (1968) has observed that the research on methods of teaching science in India has not kept pace with the breadth and rapidity of scientific advancement in this country and the tremendous importance of science teaching in general. He further observes that no research work at Ph. D. level has been conducted in this area and only a few research studies at the M. Ed. level are available.

Table I provides an information about the different areas covered by the different researchers in the Indian universities :

TABLE 1

Classification of Studies on Methods of Teaching

(Area–Wise)

Sub-Areas	Frequency	Rank	Percentage
I. Use of Two methods	5	1	35.7
II. Discovery, Laboratory, Experimentation, Project, Problem-Solving, Heuristic	4	2	28.6
III. Lecture-cum-Demonstration	3	3	21.4
IV. Methods based on the use of Mechanical Devices.	2	4	14.3
Total	14	—	100.00

TABEL 2

Classification of Studies on Methods of Teaching

(University-wise)

University	No. of studies					Percentage
	I	II	III	IV	Total	
1. Aligarh	1	—	—	2	3	21.5
2. Allahabad	—	—	1	—	1	7.1
3. Baroda	—	1	—	—	1	7.1
4. Delhi	2	—	—	—	2	14.3
5. Madras	1	1	—	—	2	14.3
6. Mysore	—	1	—	—	1	7.1
7. Osmania	1	1	2	—	4	28.6
TOTAL	5	4	3	2	14	100.0

The Actual Position

Nearly 404 studies have been conducted so far in the field of science education at Ph. D. and M. Ed. levels in various Universities, in this country. Only 14 studies, that is, 3.5 per cent have been conducted in the area of Methods of Teaching Science, which may be divided into four broad areas such as Lecture-cum-Demonstration, Discovery, Laboratory, Experimentation, Project, Problem Solving, method based upon the use of Mechanical Devices; and the use of two methods or comparison of two methods.

The first place in the rank order has been secured by the category where researchers used two methods, or compared two methods to find out the effectiveness of one method over the other. The total number of such studies is 5 or 35.7 per cent of the total number of studies in this field.

The second place has been occupied by the category, namely Discovery, Laboratory, Experimentation, Project, Problem-solving with 4 or 28.6 per cent studies to its credit. In this category, studies have been conducted to determine the relative educational value of two methods such as demonstration and laboratory; traditional and problem solving; observation and experimentation, etc.

Studies of an experimental nature have been conducted to find out the relative merit of lecture and demonstration methods. The number of such studies is 3 which occupies third rank with 21.4 per cent.

The category, namely methods based upon the use of mechanical devices indicate 2 or 14.3 per cent studies and occupy the fourth rank. Both of these studies have been done on Programmed Instruction. In one of these studies the effectiveness of Programmed Instruction in Physics has been studied while in the other a comparison has been made between Programmed Instruction and Conventional Methods. Both these studies have been conducted in the same subject, Physics.

The analysis of research shows that only seven universities have encouraged studies on the Methods of Teaching Science. The highest number of studies 4 or 28.6 per cent have been carried out in Osmania University. The second rank has been occupied by Aligarh University with 3 or 21.5 per cent studies to its credit. The third rank has been shared by Delhi and Madras universities where 2 or 14.3 per cent studies have been conducted in each of these universities. 1 or 7.1 per cent studies have been conducted in each of the three universities of Allahabad, Baroda and Mysore.

The above mentioned analysis confirms the reporting of Pillai (1968) that the universities of Calcutta, Gorakhpur, Jabalpur, Rajasthan, Utkal and Vikram have conducted almost no research on methods of teaching science. No university has covered all the areas of this branch of knowledge.

It has been observed that most of the researches have used questionnaire technique and some of them have used experimental and control groups for teaching two different methods. Surprisingly, a thorough study of the dissertations indicated that researchers did not equate the two groups on any sound methodological basis. This analysis further shows that many important variables were not taken into consideration.

Another observation is that appropriate statistical techniques required by the nature of the data and the different groups have not been used.

Experimental studies are very few and researchers have only emphasised inquiry approach or discovery learning. However, few researchers have emphasised Programmed Learning also.

Most of the researches have only local reference and it will not be, perhaps, relevant to generalise with sufficient exactness for larger samples.

One important phenomenon is the attempt of some researchers to use the Philosophy of Science in the teaching of science. But only one study has been attempted in this direction. Many more studies of this nature are needed so that some trends may be established with confidence.

Neglected Areas

Reasons for the neglect of certain methods of teaching science are difficult to speculate but it appears that most of the colleges where science education is taught do not initiate the student-teachers to conduct research on different methods of teaching science. It is apparent that neither the teacher-educators nor the teachers have realized the significance of these methods in teaching. Moreover, the relative importance of new methods of science teaching has not been realized to a great extent.

It is also evident that no relationship has been established between the methods of teaching and the learning theories. Even those studies which are related to Programmed Learning lack such relationship.

Another observation is that there is no clear indication of the relationship of teaching methods to the outcomes of science education. On the basis of the above analysis it is evident that no attempt has been made to find out :

1. The effect of discussion method on learning
2. The affect of Heuristic method on learning
3. The relationship of problem solving and concept formation
4. The relationship of method with the acquisition of concepts of science.

The data analysed above indicates that researches on important instructional procedures, which have direct bearing on science teaching, need priority in this country. The procedures such as inductive or deductive, individualized instruction, programmed instruction, and inquiry approach should be tested for the development of science concepts, attitudes, problem solving skills, creativity, and the understanding of content. The focus should be on the development of outcomes of science teaching in their relationship to methods of teaching. In a developing country such as India, the use of audio-visual aids in science teaching should be given proper place in school programmes. The use of films and television for teaching, may bring a desirable change in teaching methodology. Some of the important concepts to be considered are : how can aids best be used in an instructional situation ? what is their effect on student achievement and attitudes ? and how can they improve classroom performance ?

Programmed Instruction has received some attention from the researchers. Such methods, it is hoped, will encourage individual student work and may be used extensively. Individualised instruction can play a significant role in developing certain abilities which help the learner in "learning how to learn". Instruction may be characterised as individualized if experiences are specifically designed for each individual learner, taking into account such factors as background, knowledge and experience, reading level, interest and intelligence. Such studies may be attempted in the Indian classrooms.

Studies are needed to investigate the development of critical thinking in children through suitable methods. The studies, determining the problem-solving behaviours of children at various grade levels may be encouraged. During the last twenty years much emphasis has been placed on the development of process skills in science and the use of inquiry methods to develop ceatain cognitive ablities. Researches in this area are needed if new instructional procedures are to be developed. The individual needs of students at each stage in their development may also be considered. There is a possibility that inquiry methods, laying emphasis on processes of science, may produce different outcome than the conventional procedures. Increased research is essential to determine the expected and actual growth of the outcomes of science teaching. In the light of the above observations the few following problems deserve immediate attention :

Needed Research

1. The effect of different instructional media upon the attitudes of students towards science and scientists.
2. A study of the effect of films or television instruction on science achievement and attitudes of children.
3. The differential effects upon the learning of science concepts of two modes of teaching over television in the classroom.
4. An experimental study to determine the effects of teaching through television on the achievement and interest in science.
5. A study of the effectiveness of role playing in the teaching of science.
6. Measurement of the outcomes of laboratory work in science teaching.
7. A comparative study of demonstration method and individualised laboratory work in science.
8. The influence of programmed material on pupil achievement in science.
9. A comparative study of programmed science materials and individualized work.
10. An experimental study in the programming of science instruction for ninth grade.
11. A study of the relationships between achievement, I. Q. and reading level of students of different grades using programmed science materials.
12. A study of inquiry training through programmed instruction.
13. A study of the effectiveness of selected creative exercises in science on creative thinking.
14. A study of the development in logical judgement in science through different methods of teaching.
15. An analysis of the problem solving behaviour developed through experimentation in teaching science.
16. Relationship of non-cognitive measures to different science methods.
17. Effectiveness of various methods in student achievement in science at different grade levels.
18. Developing and testing a learning model for analysing teaching methods.

19. Developing and testing various methods of teaching-learning theories and teaching strategies.
20. Studying the relationship and suitability of a method to a particular subject, in this case science.
21. The effectiveness of a particular method or methods in the development of science concepts.
22. Judging the relationship of methods, history of science, and the philosophy of science.
23. Determining the role and effectiveness of teaching science through television (computer-assisted).
24. Determining the effectiveness of field trips and self-study in science.
25. Determining the role of process approach in the teaching of science.

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Research on Instructional Material

There is no denying the fact that the key note of education is communication, a-give-and-take of ideas which blend into mutual understanding of a theory, principle or fact. If education is to fulfil its primary function of transmission of culture and also the recreation of culture thus assisting the young children to become dynamic and creative adults, more emphasis has to be placed on an understanding and appreciation of the communication processes. This also underscores the fact that more and more attention has to be devoted to the improvement of the effective techniques of communication.

Learning is an outcome of an effective communication between the teacher and his pupils. It is best effected by concrete, direct and first-hand experiences. But unfortunately teachers, by and large, are often unable to give students first hand experiences and they normally resort to an 'economical', though ultimately costly, method of communication-the use of words-both written and spoken. The use of 'inert' words, more often than not, leads to fatigue and monotony which in its turn hampers learning.

The age of automation and technology has made available to the teachers a vast array of instructional material and equipment. These materials and equipment are actually the tools of great significance and relevance to teachers in their class-rooms. They facilitate learning and provide necessary motivation to the students in the learning processes. They also add zest, interest and vitality to any learning situation. This in its turn enables the students to learn at a quicker pace, acquire more accurate information and make clear difficult concepts and their various shades of meaning.

In advance countries like USA, many investigators are engaged to prove the efficacy and superiority of the varied instructional media, like Radio-broadcasts, Telecasts and Computerised Instruction on a commercial scale.

Out of 320 references under the Audio—Visual Section of the *Encyclopedia of Educational Research* (1960), more than 200 studies and references refer to the use of Radio, films and film-strips, auto-instruction, television (both open and closed circuits), videotape and language laboratories etc, for educational communication. This clearly indicates the important contributions of modern technology in strengthening teaching-learning processes by providing vicarious contrived experiences to the learners in the West.

In contrast to phenomenal advances made in other countries the state of research in Science Education is very spotty and thus far from satisfactory in our country. Very few investigations have been attempted and reported in the field of science education. Out of approximately 404 studies in science enucation reported so far, only 49 or 12 per cent studies pertain to Instructional Material. An attempt has been made through these studies to test the efficacy of the simplest audio-visul aids like charts, models, text books, programmed instruction, etc. Only two studies pertain to radio broadcasts and only one film sought to demonstrate the empirical evidence of the utility for instructional purposes. This represents but a simple step in a vast area of research on instructional material.

A detailed analysis of the studies in Instructional Meterial is presented in Table I.

TABLE I

Classification of Studies in Instructional Material

Area	Frequencies	Percentage
(a) Audio-Visual Aids		
(1) Use of Audio-Visual Aids in Teaching	12	80.00
(2) Efficiency of Audio-Visual Aids	1	6.66
(3) Educational Significance of Toys	1	6.66
(4) Critical Study of Visual Perception and its Relation with Achievement.	1	6.66
Total	15	99.98

Area	Frequencies	Percentage
(b) Community Resources		
(1) Radio Broadcasts	2	50·00
(2) Films	1	25·00
(3) Museums.	1	25·00
Total	4	100·00
(c) Books and Journals		
(1) Critical Study of Science Text Books	11	57·90
(2) Analysis of Concepts in Science Teaching	4	21·05
(3) Criteria for writing and selecting Science Text Books	2	10·52
(4) Survey of Science Literature	1	5·26
(5) Survey of Existing Magazines, Newspapers, etc. in fostering Scientific Outlook.	1	5·26
Total	19	99.99
(d) Improvised Apparatus		
(1) Teaching of Science with the help of Inexpensive Improvised Science Apparatus.	1	100·00
Total	1	100·00
(e) Programmed Instruction		
(1) Enquiry with the facilities for Experimental work	1	50·00
(2) Comparative Study of Programmed and Conventional Methods of Teaching Science.	1	50·00
Total	1	100·00

(A) The total number of studies on Instructional Material is 41, i. e., 10·25 per cent of the total number of studies reported in science education at various universities that constitute the sample of this study.

This area of science education was further divided into five broad sections for an in-depth study. The sections are reported in Table I. A close analysis of this Table leads to the following observations :

1. The most important area, on the basis of the above Table is that of books and journals for Science instruction. The number of studies reported in this area is 19 or 46·34 per cent. This percentage obviously indicates the popularity of this area with the researchers.

2. The next, important area pertains to the use of audio-visual aids for instructional purposes. The number of studies is 15 or 36·6 per cent.

3. There is a great paucity of studies in the areas of the utilization of the community resources, improvized apparatus and programmed instruction, which stand at nearly 10. 2.5 and 5 per cent, respectively of the total number of studies reported on Instructional Material.

A detailed analysis of the studies on different aspects of the Instructional Material leads to the following conclusions :

1. Audio-Visual Aids

(a) Fourteen out of fifteen studies on Audio-Visual Aids have been conducted on the use of the audio-visual aids for instructional purposes in Science; three pertain to the efficacy for the middle standard and the remaining cover the secondary stage of education. Only one study has been conducted on the relationship of visual perception with the achievement in Science.

2. Text Books

(a) Seventeen studies on different aspects of the text books in Science subjects have been reported. Three of these studies pertain to the analysis of the concepts in General Science text books for standards VI through VIII.

(b) Only two out of the seventeen studies conducted on text books have formulated the criteria for writing and selecting text books in General Science.

(c) The largest number of studies, i. e., 10, pertain to the area of the critical study of Science text books. Two of these, however, pertain to the books written in the regional languages, i. e., Tamil and Marathi.

(d) One study has been reported on the use of journals, magazines, etc. in fostering the scientific outlook. One study surveyed the condition of science library in the schools.

3. Community Resources

(a) Only four studies have been conducted on the utilization of community resources for instructional purposes.

4. Programmed Instruction

The two following studies on programmed instruction have been conducted at Aligarh University :

(i) The effectiveness of programmed instruction in Physics-experimental findings, and

(ii) Comparative study of programmed and conventional methods of teaching Physics.

5. Improvised Apparatus

Osmania University has reported the following study on the use of improvised apparatus :

"Teaching of Science at the middle and primary stage with the help of inexpensive improvised science apparatus."

(B) The reported studies from various Indian universities on different aspects of instructional material do not provide sufficient evidence about the efficacy of improvised apparatus, programmed instruction and community resources. These materials have not been adequately explored for their usefulness for instructional purposes. Studies have also been repeated by the researchers in different universities. These studies have been conducted at district or state level. No study, however, has been reported at the national level.

Table 2 summarizes the studies conducted at various universities on different areas of Instructional Material.

TABLE 2

Studies on Various Areas of Instructional Material at Different Universities

S.N.	Universities	*A.V.	B.&.J.	C.R.	P.I.	I.A.	Total
1.	Anamalai	—	2	—	—	—	2
2.	Aligarh	—	—	—	2	—	2
3.	Allahabad	1	1	—	—	—	2
4.	Andhra	2	—	—	—	—	2
5.	Bombay	—	2	1	—	—	3
6.	Delhi	—	3	—	—	—	3
7.	Kerala	1	—	3	—	—	4
8.	Madras	6	1	—	—	—	7
9.	Maharaja Sayaji Rao	—	1	—	—	—	1
10.	Nagpur	1	1	—	—	—	2
11.	Osmania	2	2	—	—	1	5
12.	Patna	1	—	—	—	—	1
13.	Punjab	—	2	—	—	—	2
14.	Sardar Patel	—	1	—	—	—	1
15.	Saugar	—	2	—	—	—	2
16.	Vikram	1	1	—	—	—	2
		15	19	4	2	1	41

An examination of the above Table points to some important observations. The total number of studies in the area of Audio-Visual Aids is only 15 or 36·6 per cent. But all the universities have not considered this area significant from the point of research. Nine universities have not attempted even a single study. It is only the University of Madras that leads with 6 or 14·63 per cent while seven other universities have one or two studies to their

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*A.V.—Audio-Visual Aids
B&J.—Books and Journals.
C.R.—Community Resources.
P.I.—Programmed Instruction
I.A.—Improvised Apparatus.

credit, which is, by no means, significant. Again, in spite of the fact that 19 or 46·34 per cent studies have been conducted on the utility of books and journals as aids to instruction by various universities under study, none of them have more than seven per cent to their credit. Five universities have not touched this area in the least. In the area of community resources, programmed instruction and the improvised apparatus the position is hardly satisfying.

The total picture that emerges from the above Table regarding the status of Instructional Material is a dismal one. Recognizing the importance of instructional material in the teaching–learning process, the conclusion is inevitable that hardly any serious thought has been given to this area by the centres of higer learning. It is recognised that there are some in-built difficulties but attempts to remedy the situation cannot be long delayed only because the understanding of science by the young can hardly be compromised with.

Needed Research

1. A survey of the local resources for instructional purposes.
2. A study of the attitude of teachers and students towards the use of audio-visual aids.
3. An investigation into the feasibility and usefulness of mobile science shows for instructional purposes.
4. An investigation into the role of mass media in improving science teaching and interest of students in the subject.
5. A comparison of improvised and sophisticated apparatus in the teaching of different science subjects.
6. A study measuring the effectiveness of sound pictures as teaching aids.
7. A survey of the problems related to pre-and-post telecasts in the schools.
8. An analysis of the prescribed courses in teachers' training colleges for the identification of content and training provided in audio-visual education.
9. A study of the concepts in different syllabi of science subjects and finding out the efficacy of various instructional materials for action.

10. A study to determine the relationship of students vocabulary and technical terms used in science text books.
11. Development and validation of tools for the selection of different audio-visual aids.
12. A quantitative analysis of science text books based on Romey's Discovery Approach.
13. A study of school teachers' competence in the use of audio-visual aids.
14. A survey of different units in science subjects which can best be taught and learnt by different media.
15. A study of students' reactions to educational films.

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Research in Evaluation

Ever since the formalisation of education, deliberate attempts have been made in one form or the other to measure the efficacy of instruction. Teachers with an understanding of pupil's entering behaviour plan and execute the learning experiences to help him attain the instructional objectives. A historical perspective in education reveals that examinations which ought to have been integral to education, continue to dominate education to an extent that it (education) is known as examination-oriented. *The Report of the Secondary Education Commission* (1952-53) also mentioned, "the examinations determine not only the contents of education but also the methods of teaching, infact the entire approach to education. They have so pervaded the entire atmosphere of school life that they have become the main motivating force of all efforts on the part of pupil as well as teacher." Thus, any reform in education cannot be envisaged in isolation from evaluation.

Education is concerned with the sole aim of developing the total personality of the child. An increasing emphasis is on the personal and social development, as well as on academic achievement. Thus, the narrowly conceived examinations which are concerned with the testing of academic attainment, have become a part of a broad term-evaluation.

Broadly defined, educational evaluation is the estimation of the growth and progress of pupils toward objectives or values in the curriculum. The purposes of evaluation are to provide for the collection of evidences which will show the degree to which pupils are progressing toward curricular goals, and to permit teachers and supervisors to evaluate the effectiveness of curricular experiences, activities, and instructional methods. The functions of evaluation are to make provisions for guiding the growth of individual pupils, to diagnose their weaknesses and strengths, to point out areas where remedial measures may be desirable, and to provide a basis for the modification of the curriculum or for the introduction of experiences to meet the needs of individuals and groups of pupils.

Professor Bloom has emphasized the triangular relationship of objectives, learning experiences and evaluation. An evaluation, programme is interrelated with curriculum because it is an integral part of guiding pupil experiences. All evaluative tools and techniques provide evidence for judging growth towards curriculum objectives. The evidence so gathered in turn, affects the curriculum by indicating those areas in which students' achievement is not as effective as may be desirable, and by indicating those activities and experiences which may not be conducive to pupil development as others. Thus, the evaluation programme becomes a means not only for guiding the pupil's growth but also for indicating changes that may be necessary in the design of the curriculum and in the conduct of instructional practices. This feedback, characteristic of evaluation, necessitates a continuous and systematic research on evaluation in science teaching to enhance the progress of students' performance and improvement of curricular programme in the schools.

A large number of research studies in the area of evaluation in science education have been reported abroad. These studies have a wide coverage of the different aspects of evaluation ranging from students' academic performance to the evaluation of curriculum, total school environment and other factors influencing pupil personality growth.

TABLE 1

Classification of Studies in Evaluation

S.N.	Area	No. of studies	Percentage
1.	Achievement Tests		
	1.1. Curriculum-oriented tests	35	39·8
	1.2. Objective-oriented tests	3	
	1.3. Minimum Essentials tests	1	
2.	Diagnostic Tests, Diagonsis of Learning Difficulties	19	19·4
3.	Aptitude and Interest tests	10	10·2
4.	Measurement of Conceptual Attainment, Understanding	6	6·12
5.	Factors affecting Achievement, Correlation of Achievement	5	5·1
6.	Factors affecting Aptitudes and Interests	5	5·1
7.	Comparison of different types of tests	5	5·1
8.	Prediction of Achievement	3	3·06
9.	Comparison of the performance in different areas of science	2	2·04
10.	Rating scales for Evaluating Teaching	2	2·04
11.	Factors which discriminate between Achievement Levels	2	2·04
	Total	98*	100·00

*Though the total number of reported studies here is 156, it is only 98 that have been classified.

A careful observation of Table 1 leads to the following broad conclusions :

1. The list of studies reported in the area of evaluation are 156 and out of them only 98 (nearly 63 per cent) studies could be classified under eleven different aspects as indicated in the Table under reference.

2, 39 out of 98 studies reported in evaluation pertain to achievement tests. This aspect covers 39.8 per cent of the studies reported on evaluation in science education. Thus, a major emphasis is given to the evaluation of scholastic performance of the students.

3. An analysis of the 98 studies indicates that achievement tests in science mainly cover General Science which is more often used as one of the criteria for predicting student's further achievement. Only a meagre number of achievement tests in Chemistry, Physics, Mathematics and Biology have been developed and used.

4. The second major aspect of evaluation in science which covers 19 studies (19.4 per cent) is diagnostic tests and diagnosis of learning difficulties. This aspect of evaluation is directly ,related to the feed-back function of evaluation and more concentrated efforts are required to be directed to this aspect.

5. The three following aspects which appear to be equally important for the improvement of science education cover only 2 studies each :
   (a) Factors which discriminate between achievement levels
   (b) Comparison of the performance in different areas of Science
   (c) Rating scales for Evaluating Teaching.

6. No study has been reported on the self-appraisal of scholastic attainment by the students.

The relative importance given by researchers to Evaluation in science education at different universities in this country is presented in Table 2.

TABLE 2

University Wise Classification of Studies on Evaluation

Name of University	Area	1.1	1.2	1.3	2	3	4	5	6	7	8	9	10	11	Total	Percentage
Agra		3	—	—	1	—	—	1	—	—	1	—	—	–	6	6.12
Aligarh		1	—	—	—	1	1	—	—	—	—	1	—	–	4	4.08
Andhra		2	—	—	—	—	—	—	—	—	—	—	—	–	2	2.04
Baroda		1	—	—	—	1	—	—	—	—	—	—	—	–	2	2.04
Bombay		2	—	—	—	—	—	—	—	—	—	—	—	–	2	2.04
Delhi		2	—	—	—	—	—	—	—	—	—	—	—	–	2	2.04
Gorakhpur		2	—	—	—	—	—	—	—	—	—	—	—	–	2	2.04
Gujrat		2	—	—	—	—	—	—	—	—	—	—	—	–	2	2.04
Jamia		1	—	—	—	—	—	—	—	—	—	—	—	–	1	1.02
Jabalpur		2	2	—	—	—	—	—	—	—	—	—	—	–	4	4.08
Kerala		11	1	1	11	2	5	2	2	5	1	2	1	2	46	46.92
Lucknow		2	—	—	2	1	—	—	—	—	—	—	1	–	6	6.12
Madras		—	—	—	4	1	1	2	—	—	—	1	—	–	9	9.18
Nagpur		3	—	—	—	—	1	—	—	—	—	—	—	–	4	4.08
Osmania		—	—	—	—	—	—	—	—	—	—	1	—	–	1	1.02
Sardar Patel		—	—	—	—	—	1	—	—	—	—	—	—	–	1	1.02
Utkal		1	—	—	1	—	1	—	—	—	1	—	—	–	4	4.08
		35	3	1	19	6	10	5	2	5	3	5	2	2	98	99.96

1. Table 2 reveals the contribution of various universities in India to the area of evaluation in science education. It is astonishing to observe that out of about 80 universities in India, only 17 have contributed to the area of evaluation in science teaching.

2. Kerala University has reported the largest number of studies i.e., 46 which is 46·92 per cent of the total 98 studies in evaluation in science education. The next position is occupied by Madras University which has reported 9 studies i.e., 9.18 per cent.

3. Three out of the 17 universities contributed only one study each. These universities are : Jamia, Osmania and Sardar Patel.

Analysis of the test titles indicate that certain areas such as achievement tests are over-represented whereas certain very-needed areas have not been touched. It is to be noted in particular that for Science almost all the old tests are outdated and useless because the whole set of objectives have changed recently in these subjects.

The data presented in Tables 1 and 2 confirm the paucity of studies in the area of evaluation in Science Teaching not only in quantity but in quality also. It is evident that one of the most important areas which has not received the attention it deserved is the evaluation of curriculum in science education. No doubt new science curricula have been put into the market as a result of the efforts of some scholars but it is important to remember that "development is an engineering process designed to produce products (Romberg, 1969) and, therefore, the only way to establish quality is by systematic evaluation." It is not only necessary to test student's performance on some tests at the end of the instruction but it is also essential to evaluate the utility (or futility) of what has been studied when the student has gone out of school/college and entered the mainland of life. For instance, one would like to evaluate whether the teaching of Science has, in general, led to scientific attitude and scientific exactitude. Again, has it kindled an interest, at least in a minority of students, to further penetrate the mysteries of Nature? Or, alternatively has it stopped at the stage of what Nunn (1938) called "wonder" or has it gone to the stage of "precision" or systematization in the case of a few at least ? These are hard questions but need an immediate answer.

Needed Research

The following areas in the field of science education have not been properly investigated. There is an immense need for research studies to be undertaken in the following suggested topics for making evaluation of science education more comprehensive and useful :

1. Teacher Made Vs. Standardized tests.
2. Test Interpretation, Prediction.
3. Critical Assessment of Standardized Tests.
4. Developing comprehensive curricular objectives under Indian conditions.
5. Interrelationship of cognitive, affective and psychomotor dimensions.
6. Product and process evaluation (Geometric diagrams, Science Diagrams, Experimental designs).
7. Utility of items for measuring different types of objectives in Science.
8. Differential aptitude measures in relation to success in different subjects (Spatial).
9. Scientific creativity, attitude towards problem solving, scientific attitude scales.
10. Evaluation of school personnel.
11. Self evaluation tests.
12. Rating of teacher effectiveness by administrators and pupil rating of teachers.
13. Tests for generalized skills : diagram drawing, Science vocabulary, critical thinking, etc.
14. Evaluation practices in different schools for science.
15. Tools for New Science and Mathematics.
16. Internal assessment in Science.
17. Reliability and validity of common examination in Science.

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Research In Science Teacher Education

The teacher constitutes the most important element in teaching and Henry Adams, the historian-philosopher, was abundantly correct when he remarked that "a teacher effects eternity, he can never tell where his influence stops". A painstaking and understanding teacher may make all the difference in the lives of children. "The identification of qualified and able teaching personnel" writes Rayans (1960) "constitutes one of the most important of all educational concerns." Therefore, any teacher-education programme which is not sound at all levels, that is, from elementary to higher secondary level, rigorous improvement cannot be brought about in the process of teaching and learning.

In the post-independence era in India there has been a growing realization of the importance of Science and Science Education. As a result of it, teachers colleges have started M.Ed. programme in Science Education. The Regional College of Education, Ajmer, launched an M.Ed. programme with specialisation in Science Education exclusively. Other Regional Colleges of Education at Mysore, Bhopal and Bhubaneswar have followed suit. As a result of such efforts some research studies in Science Education have been taken up. The areas covered are, by and large, inter-action analysis, attitude of prospective science teachers towards the profession, personality studies of science student teachers, attitude of science teachers and students towards science and scientists. There are a few studies in creativity and science education.

A number of studies have been conducted in U.S.A. in this area but as Ryans (1960) remarks most of the studies on all aspects of teachers have accumulated in a haphazard fashion with little attention given to organisation and systematization of research facts or to the assumptions and definitions upon which studies may be based. Therefore, efforts have to be made persistently to form its theoretical and conceptual framework.

Obourn (1960) who reviewed the situation of research in Science Education, before the National Association of Research in Science Teaching (USA) expressed a great dissatisfaction with the quality of research in Science Education. Similarly Anderson and Smith (1960) also noted that "there is obviously a need for a more thorough-going consideration of evaluative techniques and procedures and for the planning of comprehensive educational research efforts as part of these experimental programmes which commit vast sums of money and time of millions of pupils."

Blosser and Howe (1967) state that since 1964 there has been an increase in the amount of research on programmes for educating science teachers. Such studies still, however, are few in number. Most of the investigators have focused on verbal interaction analysis, micro-teaching situations, simulatation analysis and general outcomes of teacher education programmes.

Again Corrigan (1967) stated that apparently there are no studies of teaching at present that will yield the broad, predictive generalizations that are a long-range goal of inquiry into teaching. Descriptive studies of teaching, however, serve an essential pre-requisite to subsequent investigations which may yield such generalisations, etc. etc. Seetman (1972) observes that research in Science Education has given little returns over the past thirty years. He cautions that one has to revise his thinking about the meaning of the term" vigorous" as applied to research. He strongly suggests that it is extremely essential to remember the fact that classroom teachers have to be helped in functionally utilising the results of research that has been done in the field.

Another important area that has attracted the attention of the researchers in the education of science teachers is that of teacher effectiveness. Though teacher effectiveness to date has not been operationally defined on which the nations educators could express a broad agreement, here and abroad it has not prevented researchers to set up what Thorndike (1949) calls immediate criterion and planned their research designs accordingly.

In order to bring an improvement in science teaching, researchers on teacher effectiveness are attemping to investigate the competencies that should be developed in prospective as well as in-service teachers. The assumption implicit in such an exercise is that teaching competencies can be identified and measured with valid and reliable tools. The overall effectiveness is defined operationally in terms of student growth in one basic skill which would consequently stimulate the greatest growth in other skills. Bohn and Raun (1970) investigated teacher characteristics which appear to predict successful teaching of an innovative curriculum. But Ryans (1941) pointed out long back that teacher effectiveness is contributed to by many qualities of an individual-intellectual and personal. Perhaps, the teacher's subject-matter competence may also contribute to a prospective and in-service teacher's professional competence. The research evidence is conflicting. One may conclude from the available research studies on teacher effectiveness that the state of art in Science Teacher Education, as in other areas, is not settled finally.

Bruce (1969) is not pessimistic and discerns "some straws in the wind that indicate an increased movement towards reconstructing science teacher education on the basis of valid research evidence." Perhaps, it is due to the appeals made by Watson (1963) that greater attention is being given now to such areas as the science teacher's personality and its relationship to teacher education.

It would be interesting to analyze the work done in the various areas of research in science teacher education in this country. Out of 404 studies available, only eight studies deal with pre-service and in-service teacher education. These eight studies may be broadly classified into the following categories and are given in Table 1 and 2 :

Table 1

Studies related to Pre-service Teachers.

Category	N	Percentage
Evaluation of Achievements of Student Teachers	2	25.00
Effectiveness of the Methods	2	25.00
Problems Pertaining to Pre-service Training	2	25.00
Attitude Towards Syllabus	1	12.50
Subject Competency	1	12.50
Total	8	100.00

Iable 2

Studies Related to In-service Teachers.

Category	N	Percentage
Attitude Towards In-service Programmes	3	37.50
Problems Pertaining to In-service Training	3	37.50
Attitude Towards Syllabus	1	12.50
Consultancy Service	1	12.50
Total	8	100.00

A study of Tables 1 and 2 lead to the conclusion that only 2 percent of the total of 404 studies each have been made in the pre-service and in-service research in Science Teacher Education. The percentage is appallingly low and points to the almost total neglect of researches in this important area. Be that as it may, a relatively greater attention (25.80 per cent each) has been given to evaluation of achievements of student teachers. Effectiveness of methods and problems pertaining to pre-service training, attitude towards syllabus and subject competence of the pre-service student teachers claim 12.5 per cent each.

The story is not dissimilar at the in-service stage. Attitude towards in-service programmes and problems pertaining to pre-service training have been investigated to the extent of 37.50 per cent each, while attitude towards syllabus and consultancy service claim 12.50 per cent, each.

The conclusion, from the available studies in research in Science Teacher Education, is that not only meagre attention has been paid to this important area but significant areas (to which a reference will be made in the subsequent pages) have been sorely neglected. Again, it is not possible to envision some important leads from the 2 per cent out of a total of 404 available studies conducted in the area of research in Science Teacher Education, which may rightly be called one of the significant areas of Science Education.

Table 3

Studies On Various Areas Of Science Teacher Education— Pre-service at Different Universities

Universities	Area					
	E.A.T	E.M.	A.S.	P.P.	S.C.	Total
Kerala University	2	2	1	1	1	7
Delhi University	—	—	—	1	—	1
Total	2	2	1	2	1	8

E.A.T. = Evaluation of Achievements of In-service Student Teachers.
E.M. = Effectiveness of Method.
A.S. = Attitude Towards Syllabus.
P.P. = Problems Relating to Pre-service Training.
S.C. = Subject Competence

Table 4

Studies on the Various Areas of Science Teacher Education— In-service at Different Universities

Universities	Area				
	A.P.	P.S.	A.S.	C.S.	Total
Rajasthan University	1	–	–	–	1
M. S. Baroda	2	–	–	–	2
Bombay	–	1	–	–	1
Patna	–	1	–	–	1
Delhi	–	1	–	1	2
Punjab	–	–	1	–	1
Total	3	3	1	1	8

An examination of Tables 3 and 4 lead to some important conclusions. Out of 100 universities in India it is only Kerala University that has devoted a fraction of its attention to research in Science Teacher Education at the pre-service level. Delhi University has only one study out of eight studies to its credit in this area. At the in-service stage the position is rather diffused. M. S. Baroda and Delhi Universities have two studies each to their credit, while Rajasthan, Bombay, Patna and Punjab have one each to their credit. Perhaps, the conclusion that research in Science Teacher Education has been, by and large, neglected by the Indian Universities is not untenable. And, it is hardly flattering. This conclusion, it may be noted, is based on 404 studies available at the moment. There is a possibility of some omissions but even then the number of studies concerning teacher education compared to the total number of studies in Science Education is extremely small.

Whatever research has been done is in general unplanned, and perhaps, not directly and functionally related to the education of pre-service and in-service teachers. Many researches highlighted abroad have not made any significant dent in this area in this country.

Needed Research

The following are some of the problems that need further research in the field of Science Teacher Education in this country :

1. How can coordination be affected between and among teacher training institutions, university departments of education, state departments and institutes of education for improvement of Science Teaching ?
2. Construction of a Science Education Curriculum to develop the essential competence in pre-service teachers to meet the changing needs of the schools.
3. Are dynamic methods such as discussion, seminars, workshops team-teaching, problem solving, programmed learning, auto-tutorial system, more effective than the conventional techniques in the teaching of science methods ?
4. (a) What qualities make a good science teacher ?
   (b) How can desirable attitudes be developed in a science teacher ?
   (c) What activities should be planned and executed in pre-service programme to effect their correlation with science classroom situations ?

5. (a) Relationship of internal and external assessments to :
    - (i) better learning habits,
    - (ii) reduction of anxiety about examinations,
    - (iii) development of confidence in assessment, and
    - (iv) minimizing malpractices in examination.

   (b) Better involvement of cooperating school personnel in student teaching and assessment.

   (c) Role of teacher educators, supervising teacher and the pupils in the assessment of teaching effectiveness of the trainees.

6. Construction and standardization of aptitude and interest inventories for the selection of pre-service science teachers.

7. (a) Factors contributing to a good science teacher educator ?

   (b) Identification of programmes needed to be organised to improve the professional competence of the science teacher educators.

8. Scope of science education researches in teacher training institutions.

9. Relative merit of one-year and four-year courses in the education of a prospective teachers.

10. Opinion of the principals about in-service training of science teachers.

11. Survey of the academic needs of science teachers so that in-service programmes may be organised accordingly.

12. Relationship of science teacher's behaviour, competence and characteristics to teaching success and classroom climate.

13. Desired behaviours and skills for science teachers.

14. Study of effectiveness of in-service courses in classroom situation.

15. Evaluation of in-service courses.

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A Few Suggestions

Research in Science Education in this country is not only diffused but is also confused. There has been, as is clear from the study of the previous chapters, no consistent plan or programme with the Science Teacher Educators which could act as a guide in the formulation of goals in Research in Science Education. It is, however, recognized that there have been insurmountable difficulties which have acted as a road-block in this direction. It is futile to repeat what has already been said elsewhere. However, there is a strong consensus among workers in the field of Science Education that some immediate steps be taken to set Research in Science Education on a sound footing. A few following suggestions therefore, seem to be in order:

1. A Joint Committee of the Professor of Science, Science Teacher Educators, Science Teachers in the field, Directors of Education and the representatives of the NCERT, New Delhi, may lay down in clear, precise and down-to-earth terms the goals of Research in Science Education. A sub-committee of this larger committee may diagnose important areas, lay down priorities and develop some significant guide lines for research in this important area.

2. An attempt may be made to enunciate the philosophy of teacher education with special reference to Science Education as this will provide the direction for the education of prospective and in-service teachers.

3. Experience in applied research may be a necessary qualification for appointment as teacher educators. Teacher educators may be provided with financial assistance and professional recognition in carrying out research in Science Education.

4. One of the important banes in the path of educational research in general and Science Education in particular is the effective lack of communication between and among the research workers in this country. It leads to

duplication of studies etc. It is, therefore, necessary to have an official publication issued by NCERT (like Dissertation Abstracts or Psychological Abstracts in USA) that will carry the titles and brief summaries of the investigations carried on at the M. Ed. and Ph.D. level. It will also report individual/or cooperative research studies published in this country. The periodicty may be quarterly, but it may be priced cheaply to enable a large number of interested persons to purchase the publication.

5. A liberal pooling of grants from agencies such as U.G.C. UNESCO, UNICEF, industrial concerns etc., etc. may be effected for developing research in Science Education.

6. A competent body at the national level may identify major areas in Science Education and the same may be allotted for investigation to different traininig Colleges or a group of proximate teachers colleges. The four RCEs could play a leading role in this direction with their expertise.

7. Persons engaged in Research in Science Education may be provided with adequate facilities of study leave.

8. State Institutes of Education and Science Education may undertake research work in certain areas like the evaluation of the different curricular materials. The SIE and SISE may call frequent effective workshops and seminars to discuss priority areas for researh in Science Education in their respective areas. They may pin-point certain research problems and prepare adequate research designs to be carried by their research teams.

9. Ideally every M.Ed. student should investigate a problem that is nearer to his heart. But under the conditions operating in this country the same is not true except in very extreme exceptions. It is suggested that the four Regional Colleges of Education in consultation with experts in the field of Science Education may formulate a number of problems which could be investigated by the M. Ed. students as a part of their University requirement under their supervisors.

10. The Boards of Secondary Education in the country have a wealth of data at their disposal. They may be encouraged to analyze the same.

APPENDICES

Appendix—I

List of Studies in Mathematics Education Conducted at the Ph. D. and M. Ed. Levels

S. No.	Title	Year	University
1.	Status of Mathematics in the High School Curriculum and Factors in Mathematical Attainment.	1952	Saugar
2.	Teaching Aids in Secondary School Mathematics.	1960	Patna
3.	Critical Examination of Teaching Aids in Teaching of Elementary Mathematics.	1957	Bombay
4.	A study of Pupils' Attitude to Mathematics.	1953	Allahabad
5.	A study of the Attitude of S. S. L.C. Students Who have Taken Composite Mathematics Towards the Subjects.	1955	Madras
6.	Students' Attitude towards Mathematics in High Schools (classes IX and X).	1958	Nagpur
7.	Investigation into the Causes of Failure in Mathematics in the High School Classes.	1955	Bombay
8.	An Investigation into the Causes of Errors in Geometry for class IX.	1956	Rajasthan
9.	A Study of the Relationship Between Socio-economic Status, Aptitude and Achievement in Telugu of Pupils of Form IV.	1957	Andhra
10.	An Investigation Into the Causes of Backwardness in School Mathematics with Particular Reference to 8th and 9th Grades.	1961	Osmania
11.	A Study of Cheating in Class-room Work in Mathematics.	1958	Allahabad
12.	A Critical Study of Causative Factors of Backwardness of Some Pupils in Mathematics of IV form.	1961	Andhra
13.	The Geometrical Concepts of Children of the Primary Level (Age 5 to 10).	1961	Bombay

S. No.	Title	Year	University
14.	A Study of Selected Geometrical Concepts of Class IX Students ot Schools of Jullundur District.	1958	Osmania
15.	Correlation Technique in Basic Education with Special Reference to Mathematics.	1957	Osmania
16.	The Comparative Study of Mathematics Curricula at the Primary Stage in the Different States of the Indian Republic.	1954	Osmania
17.	A Study of Factors Contributing to the Development of Aptitudes with Particular Reference to Mathematics at Secondary Level.	1961	Osmania
18.	Development of Curriculum in Mathematics for the 6th and 7th Classes of C.I.E, Experimental Basic School.	1958	Delhi
19.	A Study of the Development of Functional Thinking in Algbera in the Secondary Schools with Special Reference to Pupils in High Schools (Written in Telugu).	1954	Madras
20.	A Diagnostic Study of 500 S.S.L.C Answer Books in Elementary Mathematics.	1948	Madras
21.	An Enquiry into the Gujarati Terminology in Geometry Taught in Standards VIII and IX.	1957	Gujarat
22.	Intelligence, Achievement and Interest in Mathematics.	1959	Allahabad
23.	A study of Interst of Girls in Mathematics Classes. VII to X.	1958	Allahabad
24.	An Investigation into the Assessment of Interst of the 9th Standard Boys and Girls of the Delhi City Schools in Learning Geometry.	1955	Delhi
25.	The Problem of Teaching Mathematics in Relation to Life and Pupils' Interests.	1960	Patna
26.	Interest Test for S.S.C. Pupils.	1955	Bombay
27.	A Diagnostics study of the Teaching and Learning of Equations, Problems and Factors in Algebra.	1956	Bombay

S. No.	Title	Year	University
28.	An Investigation into the Difficulties of the Pupils of Class X (of Delhi Schools) in Solving Equations and Problems in Algebra and the Construction of a Diagnostic Test for the Same Purpose.	1954	Delhi
29.	An Investigation into the Difficulties of Pupils of Class IX (of Bangalore City Schools) in Factorization, and Construction of a Diagnostic Test for the Same Purpose.	1956	Delhi
30.	Construction of Diagnostic Test in Decimal Fractions for Class IX of Delhi Schools.	1957	Delhi
31.	Preparation of a Diagnostic Test in Decimal Fractions for Class IX of Delhi Schools.	1961	Delhi
32.	Diagnostic Tests in Algebra for Standard VIII.	1959	Gujarat
33.	A Diagnostic Test in Algebra for Beginners.	1960	Baroda.
34.	Differentiated Curricula in Secondary School Mathematics on the Basis of the Intelligence Level.	1950	Bombay
35.	Factor Analysis of Some Geometry Tests.	1954	Osmania
36.	Contribution of Indian Mathematicians.	1959	Osmania
37.	An Investgation into the Vocabulary Used for the Teaching of Mathematics in Malayalam in Secondary Schools of Kerala State.	1961	Kerala
38.	A Critical Study of Certain Topics in Elementary Mathematics in the Light of the Latest Teaching Techniques.	1946	Madras
39.	An Inquiry into the Gujarati Terminology of Algebra Taught in Standards VIII and IX of Secondary Schools (Gujarat).	1958	Gujarat
40.	Evaluation of Pupils Attainment in General Science and General Mathematics Through Dr. Bloom's Technique.	1959	Jabalpur
41.	A Critical Study of Some Methods of Testing Achievement in Mathematics in High Schools.	1952	Madras
42.	Arithmetic Test for Class VIII.	1951	Allahabad
43.	Standardization of an Attainment Test in Arithmetic for Gujarati Children of Primary Standard IV in the City of Bombay and Suburbs.	1951	Bombay

S. No.	Title	Year	University
44.	Construction of an Achievement Test in Problem-arithmetic for Children 9-11 Years of Age-Usable in Delhi State Schools.	1957	Delhi
45.	Arithmetic Achievement Test for Junior High School Stage.	1958	Lucknow
46.	Achievement Test in Arithmetic for Standard VIII: Construction and Standardization.	1957	Baroda
47.	Achievement Test in Arithmetic for Standard VIII Construction and Standardization.	1958	M.S. Baroda
48.	Construction of a Standardized Achievement Test in Arithmetic for the High School Students of the Hydrabad City.	1956	Osmania
49.	An Achievement Test in Arithmetic for Class VII.	1954	Osmania
50.	Construction of an Objective Achievement Test in Arithmetic for Class VII.	1955	Patna
51.	Construction of an Achievement Test in Arithmetic for Class VIII.	1953	Rajasthan
52.	A Study of Pupils Attitude to Mathematics.	1953	Allahabad
53.	The Attitue of Secondary School Children Towards Mathematics as a School Subject.	1961	Bombay
54.	A Study of the Attitude of S.S.L.C. Students Who Have Taken Composite Mathematics Toward the Subject.	1955	Madras
55.	Students' Attitude Towards Mathematics in High Schools (Classes IX & X).	1958	Nagpur
56.	Construction of an Achievement Test in General Science for VI Form Students.	1956	Andhra
57.	Contribution of 'N' Factor Towards Achievement in Methematics of Boys and Girls of Class VIII.	1961	Nagpur
58.	An Investigation into the Relationship Between Numerical and Inductive Reasoning Factors with Achievement in Mathematics and General Science of Students in Secondary schools.	1961	Nagpur

S. No.	Title	Year	University
59.	The Correct Position and Purpose of Mathematics in National System of Education For Children between 6-14 years.	1953	Osmania
60.	An Investigation into the Professional Preparation of Mathematics Teachers for Secondary Schools in India.	1958	Delhi
61.	An Investigation into the Influence of Rewards and Punishments on the Ability to Accomplish Assigned Tasks in Arithmetic.	1953	Delhi
62.	An Enquiry into the Common Difficulties in the Solving of Algebric Equations and the Value of Some Suggested Remedial Measures.	1952	Madras
63.	An Enquiry into Some Difficulties in the Learning and Use of Algebric Formulae with Suggestions Regarding Remedial Work.	1953	Madras
64.	An Enquiry into Difficulties in the Learning of Theoretical Geometry with Constructive Suggestions.	1953	Madras
65.	A Study of the Difficulties Experienced by Pupils in Solving Problems in General Mathematics with Special Reference to Forms I to III.	1954	Madras
66.	The Difficulties of the High School Pupils in Learning Simple and Compound Interest.	1959	Madras
67.	A Diagnostic Study of the Difficulties Encountered by the Pupils of Forms IV and V in Solving Problems in General Mathematics.	1959	Madras
68.	Difficulties of High School Pupils in the Learning of Elementary Algebra (Urdu).	1941	Madras
69.	Investigation into the Difficulties of High School Students in the Learning of Mathematics—The Reasons for and Remedial Measures (Urdu).	1943	Osmania
70.	A Comparative Study of Students' Errors in Mathematics.	1953	Allahabad
71.	Errors in Decimals.	1961	Allahabad

S. No.	Title	Year	University
72.	Preparation of Achievement Test in Arithemic for-class II.	1957	Saugar
73.	Construction of an Achievement Test in Arithmetic Prepared for class VIII.	1961	Vikram
74.	A Critical Analysis of Arithmetic Text-books Used in Marathi Primary Schools with an Objective Method for Rating Their Drill Provisions.	1947	Bombay
75.	Construction of Criteria for the Writing and the Selection of Arithmatic Textbooks and Evaluation of Few Arithmetic Textbooks Used in the High Classes of the Secondary Schools in the Punjab.	1958	Delhi
76.	A Study of Language and Arithmetic Abilities of the Children Between 8 and 13 Years in Bombay Gujarati Schools.	1958	Bombay
77.	A study of the Arithmetical Ability of Primary School Teachers Under Training.	1956	Gujarat
78.	A Diagnostic Survey of the Ability of Pupils of Classes VI and VII in Common Fractions and Suggestions of Remedial Measures for Improvement.	1956	Osmania
79.	Factor Analysis of Arithmetical Ability.	1943	Bombay
80.	Measurement of Arithmetical Ability in Kann and Primary Schools.	1942	Bombay
81.	Comparison of Arithmetical Ability of Boys and Girls of Anglo-Marathi Secondary Schools.	1944	Bombay
82.	Comparison of the Arithmetical Ability of Boys and Girls of Standard V, VI and VII of Anglo-Gujarati Secondary Schools.	1952	Bombay
83.	A Statistical Survey of the Distribution of Arithmetical Ability of Pupils in some High Schools in Madras With Special Reference to Sex and Age Difference.	1948	Madras
84.	A diagnostic Study of the Common Errors of Form VI Pupils in Learning Algebraic Fractions.	1959	Madras

S. No.	Title	Year	University
85.	A Study of Common Errors in Mathematics as Found in the Elementary Mathematics Paper I of the H.S.C. Examination Held in March 1955.	1956	Osmania
86.	An Investigation into the Common Errors in Mathematics Made by the Students of Our Schools and Some Suggestions for Their remedies.	1955	Patna
87,	Common Errors in Equation by Girls of Junior Schools in Rewa (Hindi).	1960	Saugar
88.	Correlation of Mathematics Syllabus of the Secondary schools with the Post-war Requirements (Urdu).	1945	Osmania
89.	An investigation of achievement in Mathematics in Relation to Achievement in Other Subjects in Some High School Classes.	1953	Madras
90.	Correlation Between the Achievements of Pupils in Mathematics and Other Subjects in Standard VII, Form V and VI of Some Madras Secondary Schools.	1960	Madras
91.	Intelligence, Achievement and Interest in Mathematics (age group 12-14).	1959	Allahabad
92.	A Study of the Relationship Between Attitude and Achievement in School Arithmetic.	1956	Madras
93.	A Study of the Relationship Between Attitude and Achievement in School Arithmatic.	1950	Madras
94.	A Diagnostic Study of the Teaching of Fractions With Suggestions for Remedial Teaching.	1950	Madras
95.	A Diagnostic Study of the Teaching of the Decimal Fractions with Suggestions for Remedial Teaching.	1951	Madras
96.	An Investigation into the Common Errors in Mathematics Made by the Students of Four Schools and Some Suggestions for Their Remedies.	1955	Patna
97.	A Critical Study of Mathematics Curriculum in J. H. Schools of Uttar Pradesh.	1954	Allahabad
98.	An Investigation into the Attainments in Arithmetic and Language of the Pupils of the Primary Standards Following Different Syllabi.	1954	Nagpur

S. No.	Title	Year	University
99.	A Study of Correlation of Arithmetical Problems with Life Situations.	1958	Bombay
100.	A Report on the investigation into the relationship between interest and achievement (in Arithmetic.)	1952	Dhlhi
101.	Correlation Between Achievement of High School Pupils in English Grammar and in Arithmetic.	1956	Madras
102.	Formulation of Criteria for the Writing and the Selection of Arithmetic Text Books and Evaluation of an Arithmetic Textbook Used in the Secondary Schools of Manipur and Assam.	1961	Delhi
103.	Construction of an Achievement Test in Mathematics for Class VIII pupils of Sardarshar.	1961	Rajasthan
104.	Construction of Diagnostic Test in Arithmetic for Class V.	1959	Allahabad
105.	Diagnostic Tests in Arithmetic for standard IX (Gujarati).	1960	Gujarat
106.	An Analysis of Diagnostic Test for Common Errors in Arithmetic.	1954	Lucknow
107.	An investigation into Backwardness in Arithmetic and Construction of a Diagnostic-cum-Achievement Test for Class IV.	1957	Lucknow
108.	Diagnostic Tests in Basic Arithmetics kills.	1955	Baroda
109.	Construction of Diagnostic Test in Arithmetic for Class VIII.	1961	Nagpur
110.	Diagnostic Testing in Arithmetic for Class V.	1954	Saugar
111.	Diagnostic Testing Arithmetic in Verbal Problems for Class V.	1955	Saugar
112.	Diagnostic Testing in Arithmetic for Class VI.	1959	Saugar
113.	The Study of Different Methods of Teaching with regard to Certain Problems in Arithmetic.	1958	Bombay
114.	Motivating Techniques in Arithmetic Teaching at Primary Stage.	1957	Allahabad

S. No.	Title	Year	University
115.	Constructing an Achievement Test in Arithemetic for Class VIII and its Correlational Study with intelligence.	1960	Agra
116.	Aptitude for Mathematics and a Study of the Same in Pupils of Form IV.	1956	Andhra
117.	The value of Mathematics and the Success of the Various Methods of Mathematics Teaching in Indian schools.	1961	Aligarh
118.	An Experimental Study of the Scope for Different Methods of Teaching Different Topics in Algebra.	1958	Bombay
119.	Some Problems Regarding the Teaching of Practical Geometry in Secondary schools.	1944	Bombay
120.	A Survey of Methematics Teaching in High school Classes of Greater Gwalior.	1955	Allahbad
121.	A Critical Study of the Teaching of Geometry in High schools Preparing for the Madras Matriculation Examination with Suggestions for Remedial Teaching.	1958	Madras
122.	Sequence to Theorems in the Theoretical Geometry in Secondary Schools (Urdu).	1942	Osmania
123.	Investigation into the Teaching of Mathematics in High schools of M. P.	1956	Saugar
124.	A study of Methods and Results in the Teaching of Percentages with Suggestions for Improved Methods.	1952	Madras
125.	A Critical Study of the Teaching of Percentages and its Application to Interest.	1959	Madras
126.	A Study of the Teaching of Ratio and troportion in Mathematics.	1956	Madras
127.	Construction and Standardization of an Achievement Test in Algebra for Gujarati-speaking Children.	1958	Baroda
128.	Achievement Test in Geometry.	1959	Baroda

S. No.	Title	Year	University
129.	The Construction and Standardization of an Achievement Test in Elementary Mathematic for High School Second Year Class.	1959	Mysore
130	Construction of an Achievement Test in Trigonometry for the Intermediate Classes.	1956	Aligarh
131.	Norms in Arithmetic by Schonell's Arithmetic Test.	1961	Lucknow
132.	An Investigation into the Difficulties in Problem solving in Arithmetic as Countered by Sixth-grade Students.	1952	Delhi
133.	A Study of the Difficulties Experienced by High School Pupils in Solving Problems in Commercial Arithmetic with Suggestions for Remedial Measures.	1959	Madras
134.	A Study of Students' Errors in Arithmetic.	1951	Allahabad
135.	Students' Errors in Arithmetic.	1951	Allahabad
136.	An analysis of Errors of pupils in Division with Two Digit Numbers in Standard IV.	1960	Kerala
137.	Achievement and Common Errors in Basic Number Combinations.	1954	Lucknow
138.	A Study of Errors in Arithmetic.	1955	Baroda
139.	Backwardness in Arithmetic of II plus.	1950	Allahabad
140.	An Investigation into Backwardness in Arithmetic and Construction of Diagnostic-cum-achievement Test for Class IX.	1957	Lucknow
141.	Backwardness in Arithmetic in the Primary Stage as Observed in Some Schools in Madras.	1947	Madras
142.	A Study of the Cause of Backwardness of Children in Arithmetic.	1955	Baroda
143.	Backwardness in Arithmetic : A Diagnostic Study of Children of Class VI.	1958	Rajasthan
144.	Construction of Test for Measurement of Under-Standing of Fractions, Decimals and Percents in Arithmetic of the Pupil of Class IX of Delhi City.	1956	Delhi

S. No.	Title	Year	University
145.	Attainment Test in Arithmetic.	1939	Banaras
146.	Construction of an Achievement Test in Algebra for High School Classes.	1959	Aligarh
147.	Achievement Tests in Algebra (standard X).	1957	Bombay
148.	Testing the Performance in Algebra and Geometry at the End of the Tenth Standard by an Objective Achievement Test.	1958	Bombay
149.	Achievement Test in Algebra For Childern in Standard VIII in Gujarati Medium schools.	1960	Bombay
150.	Construction of an Achievement Test in Geometry for the Students of Class VIII in High Schools of Calcutta.	1954	Delhi
151.	Construction of a New Type Achievement Test in Geometry for Class IX of the Schools of the State of the Punjab.	1955	Delhi
152.	A Study of the Examination System in India Since 1835.	1957	Delhi
153.	Construction of an Achievement Test in Algebra for Class VIII of High Schools of Birbhum District, West Bengal.	1957	Delhi
154.	Construction of a Test of Understanding in Geometry Covering the Syllabus of Class IX of Higher Secondary Schools of Delhi.	1957	Delhi
155.	Construction of an Achievement Test in Algebra for Class X (Higher Maths, Group) of Higher Secondary Schools of Delhi.	1958	Delhi
156.	Standardization of an Achievement Test in Geometry for Class IX boys of Delhi Schools.	1959	Delhi
157.	The Construction and Standardization of an Attainment Test in Algebra for Grade VIII.	1960	Gujarat
158.	Construction of an Attainment Test in Mathematics for Class IX Through Dr. Bloom's Technique.	1960	Jabalpur
159.	Objective Test in Geometry for Class IX Students.	1954	Lucknow

S. No.	Title	Year	University
160.	Interest Patterns of Adolescent Girls in Lucknow Schools.	1954	Lucknow
161.	Geometry Achievement Test for Junior High School Stage.	1959	Lucknow
162.	Algebra, Trignometry Achievement Test for Higher Secondary Stage.	1961	Lucknow
163.	Achievement Test in Algebra for Standard VIII.	1957	Baroda
164.	Achievement Test in Geometry for Standard IX. Construction and Standardization.	1958	Baroda
165.	Achievement Test in Algebra for Standard VIII. Construction and Standardization.	1958	Baroda
166.	Achievement Test in Geometry for Standard VIII. Construction and Standardization.	1958	Baroda
167.	A Critical Analysis of Arithmetic Textbooks Used in Marathi Primary Schools with an Objective Method for Rating Their Drill Provisions.	1947	Bombay
168.	A Critical Study of the Textbooks in Elementary Mathematics in Use in Secondary Schools of the City of Madras.	1948	Madras
169.	An Evaluation of Textbooks Available in 1959 Composite Mathematics for Higher Forms in Madras.	1959	Madras
170.	Formulation of Criteria for the Writing and the Selection of Arithmetic Text-books and Evaluation of an Arithmetic Textbook Used in the Secondary Schools of Manipur and Assam.	1961	Delhi
171.	The Comparative Study of Mathematics Curricula at the Primary Stage in the Different Ctates of the Indian Republic.	1954	Osmania
172.	Development of Curriculum in Mathematics for the 6th and 7th Classes of D.I.E. Experimental Basic School.	1958	Delhi
173.	Correlation Between Achievement of High School pupils in English Grammar and in Arithmetic.	1956	Madras

S. No.	Title	Year	University
174.	Critical Study of Some Methods of Testing Achievement in Mathematics in High Schools.	1952	Madras
175.	Achievement Test in Algebra for X Standard : Construction and Standardization.	1959	Baroda.
176.	Preparation of an Achievement Test in Mathematics for Class X.	1954	Nagpur
177.	Preparation of an Achievement Test in Mathematics for Class VIII.	1958	Nagpur
178.	Preparation of an Achievement Test in Mathematics for Class IX (Lower) 1961.	1961	Osmania
179.	Construction and Standardization of an Achievement Test in Mathematics for Class IX (Multi-purpose Section).	1961	Osmania
180.	Construction and Standardization of an Achievement Test in Trignometry for Second year (Intermediate) Class in Patiala Division.	1959	Punjab
181.	Construction of an Achievement Test in Algebra for Class IX.	1956	Patna
182.	Construction of an Achievement Test in Algebra for Class IX	1958	Patna
183.	Construction of an Achievement Test in Geometry for Class IX.	1958	Patna
184.	Construction of an Achievement test in Mathematics for Class VIII.	1961	Rajasthan
185.	Construction of an Achievement Test in Mathematics for Class VIII Pupils of Sardarshahr.	1961	Rajasthan
186.	Construction of an Achievement test in Mathematics for Class IX.	1953	Saugar
187.	Construction of New Type Achievement Test in Mathematics Paper I for Class X.	1954	Saugar
188.	Construction of New Type Achievement Tests in Mathematics for Class VIII.	1957	Saugar

S. No.	Title	Year	University
189.	Construction of New Type Achievement Test in Mathematics for Class XI.	1960	Saugar
190.	Construction of an Achievement Test in School Mathematics (Compulsory) for the City of Cuttack.	1958	Utakl
191.	Construction and Standardization of an Achievement Test in Algebra for Gujarati Speaking Children.	1958	Baroda
192.	The Construction and Standardization of an Achievement Test in elementary Mathematics for High School Second Year Class.	1959	Mysore
193.	Standardization of an Attainment Test in Arithmetic for Gujarati Children of Primary Standard IV in the City of Bombay and Suburbs.	1951	Bombay
194.	Standardization of an Achievement Test in Geometry for Class IX Boys of Delhi Schools.	1959	Delhi
195.	The Construction and Standardization of an attainment Test in Algebra for Grade VIII.	1960	Gujarat
196.	Achievement Test in Arithmetic for Standard VIII. Construction and Standardization.	1957	Baroda
197.	Achievement Test in Arithmetic for Standard VIII. Construction and Standardization.	1958	Baroda
198.	Achievement Test in Geometry for Standard IX. Construction and Standardization.	1958	Baroda
199.	Achievement test in Geometry for Standard VIII. Construction and Standardization.	1958	Baroda
200.	A Critical Study of Causative Factors of Backwardness of Some Pupils in Mathematics at IV Form.	1961	Andhra
201.	An Investigation of Achievement in Mathematics in Relation to Achievement in Other Subjects in some High School Classes.	1953	Madras
202.	Correlation Between the Achievement of Pupils in Mathematics and other Subjects in Standard VII, Form V and VI of Some Madras Secondary Schools.	1960	Madras

S. No.	Title	Year	University
203.	Construction of an Achievement Test in Mathematics Giving Separate Measures of Different abilities Developed Through the Teaching of Mathematics in the High Schools of the City of Cuttack.	1961	Utkal
204.	A test of Computational Arithmetic.	1959	Delhi
205.	To Estimate the Suitability of a Text-book for Geometry Prescribed in Class VI.	1954	Lucknow
206.	A Critical Study of the Textbooks in Elementary Mathematics in Use in Secondary Schools of the City of Madras.	1948	Madras
207.	An Evaluation of Textbooks Available in Composite Mathematics for Higher Forms in Madras.	1959	Madras
208.	Correlation Between Mathematical and Verbal Ability.	1961	Patna
209.	An Elementary Study of the Factors of Algebraical Ability.	1955	Bombay
210.	Mathematical Ability of Girls (Urdu).	1944	Osmania
211.	The Sex Difference in Mathematical Ability.	1957	Osmania
212.	To Construct and Standardize a Test of Mathematical ability for the Delta Class—Standard VII.	1961	Baroda
213.	Sex Differences in Verbal and Numerical Abilties of Children at Pre-adolescent and Adolescent Levels.	1958	Nagpur
214.	Diagnostic and Remedial Work for Curricular Improvement (A Study Bassed on Analysis of Home-work and Class-work of Junior Grade-Students in Arithmetic-A New Approach).	1961	Rajasthan
215.	An Enquiry into the Common Difficulties in the Solving of Algebraic Equations and the Value of Some Suggested Remedial Measures.	1952	Madras
216.	An Enquiry into Some Difficulties in the Learning and Use of Algebraic Formulae with Suggestions Regarding Remedial Work.	1953	Madras

S. No.	Title	Year	University
217.	Investigation into the Difficulties of High School Students in the Learning of the Reasons for and Remedical Measures (Urdu).	1943	Osmania
218.	An investigation into the Common Errors in Mathematics Made by the Students of Our Schools and Some Suggestions for Their Remedies.	1955	Patna
219.	The Study of Different Methods of Teaching with Regard to Certain Problems in Arithmetic.	1958	Bombay
220.	The Value of Mathematics and the Success of the Various Methods of Mathematics Teaching in Indian Schools.	1961	Aligarh
221.	An Experiemental Study of the Scope for Different Methods of Teaching Different Topics in Algebra.	1958	Bombay
222.	Backwardness in Arithmetic : A Diagnostic Study of Children of Class VI.	1958	Rajasthan
223.	Backwardness in Arithmetic of II Plus.	1950	Allahabad
224.	Scholastic Backwardness.	1951	Calcutta
225.	An Investigation into Backwardness in Arithmetic and Construction of a Diagnostic-cum-achievement Text for Class IX.	1957	Lucknow
226.	Backwardness in Arithmetic in the Primary Stage as Observed in Some Schools in Madras.	1947	Madras
227.	Educational Backwardness (Urdu).	1942	Osmania
228.	A Critical Study of the Teaching of Geometry in High Schools Preparing for the Madras Matriculation examination with Suggestions for Remedial Teaching.	1958	Madras
229.	Some Problems Regarding the Teaching of Practical Geometry in Secondary Schools.	1944	Bombay
230.	The Teaching of Mathematics in the High Schools of the United Provinces.	1948	Bombay
231.	A Critical Ttudy of Mathematics Curriculum in J. H. Schools of Uttar Pradesh.	1954	Allahabad

S. No.	Title	Year	University
232.	An Investigation into the Teaching of Mathematics in High Schools of M. P.	1956	Saugar
233.	Critical Examination of Teaching Aids in The Teaching of Elementary Mathematics.	1957	Bombay
234.	A Critical Examination of the Use of Teaching Aids in Elementary Mathematics in High schools.	1947	Madras
235.	Teaching Aids in Secondary School Mathematics.	1960	Patna
236.	Teaching Aids in Secondary School Mathematics.	1952	Saugar
237.	Construction and Standardization of an Achievement Test in Mathematics for Class IX (Multi-purpose Section).	1961	Osmania
238.	Construction and Standardization of an Achievement Test in Trignometry for Second Year (Intermediate) Class in Patiala Division.	1959	Panjab
239.	Achievement Test in Core Mathematics for Class X-Construction and Standardization.	1961	Panjab
240.	Numerical Ability and Achievement in Mathematics as Measured by New Type and Traditional Type of Examinations of the High School Students in Nagpur.	1956	Nagpur
241.	An Investigation into the Attainments in Arithmetic and Language of the Pupils of the Primary Standard Following Different Syllabi.	1954	Nagpur
242.	Correlation of Attainments in Mathematics and Mother Tongue (500 children).	1961	Bombay
243.	Analysis of Variance of Scholastic Attainment in the Branches of Science and Mathematics at the High School Level.	1960	Gorakhpur
244.	Construction and Standardization of Achievement Tests in Arithmetic for Standards V, VI and VII for Children Studying Through Marathi as the Medium if Instruction in Greater Bombay.	1964	Bombay
245.	Diagnostic Test in Arithmetic of Gujarati Speaking Children of Standards IV to VII.	1966	Bombay

S. No.	Title	Year	University
246.	Construction of a Diagnostic Test in Algebra for Investigation into the Difficulties of the Students of Class VIII in Four Fundamental Processes.	1962	Agra
247.	Construction of an Achievement Test in Geometry for Class IX and its Correlational Study with Intelligence.	1962	Agra
248.	Construction of an Attitude Scale Towards Arithmetic.	1962	Agra
249.	A Critical Analysis of Attainment Scores in Mathemetics at the High School Examination of the U. P. Board.	1965	Agra
250.	Attitude Towards Mathematics and its Relationship with Intelligence and Achievement at the H. S. Stage.	1966	Allahabad
251.	A Critical Study of the Common Errors in Mathematics of the Pupils of IX Class with Particular Reference to Arithmetic.	1962	Andhra
252.	An Investigation into Professional Preparation of Teachers of Mathematics for Secondary Schools.	1963	Andhra
253.	Construction of an Achievement Test in General Mathematics for IX Class in Secondary Schools.	1964	Andhra
254.	Construction of a Diagnostic Test in Simple and Simultaneous Equations for class XI.	1964	Andhra
255.	Construction of an Apptitute Test in Mathematics for the Pupils of IX Class.	1964	Andhra
256.	Construction of Achievement Test in Geometry for Standard X.	1962	Bombay
257.	Achievement Test in Mathematics for Students in Std. VI.	1965	Bombay
258.	To Study Interest Patterns of 50 Mathematics Teachers of Greater Bombay of 15 Years of Experience.	1965	Bombay

S. No.	Title	Year	University
259	Construction of an Achievement Test in Optional Mathematics for Class XI Students of the City of Cuttack.	1965	Utkal
260.	Construction of an Achievement Test in Arithmetic for Students of Class V of the City of Cuttack.	1966	Utkal
261.	A Study of the Attitudes of Girl Students Towards Mathematics at High School Level in Delhi (Construction of an Attitude Scale).	1963	Delhi
262.	Construction of an Achievement Test of Understanding in Algebra for Srinagar (Kashmir) School Pupils on Completion of Their IX Class Course Prescribed by the Department of Education of the Jammu and Kashmir State.	1963	Delhi
263.	Construction of a Test of Understanding of Geometric Principles, Concepts and Their Application for XI Class (Group B) of Delhi Schools.	1965	Delhi
264.	Achievement of High School Students in Different Areas of Algebra.	1963	Gorakhpur
265.	Effect of the Cultural Level of the Family on Scholastic Achievement of High School Students in Mathematics, Science, Biology and Languages.	1964	Gorakhpur
266.	Verbal and Mathematical Abilities in High Performers.	1964	Gorakhpur
267.	Diagnostic Test in Geometry for Standard VII.	1963	Gujarat
268.	Construction of an Activity Curriculum in Arithmetic for Primary Schools.	1963	Jabalpur
269.	Comparative Study of Mathematical Abilities Between Boys and Girls in Higher Secondary Schools of Jabalpur.	1966	Jabalpur
270.	An Investigation into the Causes of Backwardness in Maths. Among the Middle School Children.	1966	Jabalpur
271.	Construction of Test on Basic Concepts of Mathematics (Arithmetic) for Class VIII Pupils in Bengali Medium Schools of Delhi.	1966	Jamia

S. No.	Title	Year	University
272.	Construction of an Achievement Test in General Mathematics in Standard VIII.	1962	Kerala
273.	Construction of an Achievement Test in Arithmetic for the Leavers of Lower Primary School.	1964	Kerala
274.	Construction of an Achievement Test in General Mathematics for Standard VII.	1964	Kerala
275.	Construction of an Achievement Test in Algebra for Std. X.	1965	Kerala
276.	A Study of the Factors Related to the Poor Performance of the Teacher Trainees of Basic Training Schools in Mathematics.	1966	Kerala
277.	A Study of Problem Solving in Arithmetic Among the Students of VIth Class of Higher Secondary Schools of Punjab.	1965	Kuru-Kshetra
278.	Norms in Arithmetic by Schonell's Diagnostic Arithmetic Test.	1962	Lucknow
279.	Standardisation of Achievement Test in Mathematic for High School Classes.	1962	Lucknow
280.	A Comparative Study of Achievement in Physics and Chemistry of Intermediate Mathematics and Biology Groups.	1962	Lucknow
281.	A Comparative Study of the Achievement in Mathematics of Students Offering Scientific and Literary Groups.	1963	Lucknow
282.	Correlation Between Attitude and Attainment in Composite Mathematics in the Case of X Standard Pupils of Some Schools.	1964	Madras
283.	A Comparative Study of the Achievement in Mathematics of Urban and Rural Students of Standard X in the City of Coimbatore	1965	Madras
284.	Construction of an Achievement Test in General Mathematics for Standard II.	1965	Madras

S. No.	Title	Year	University
285.	A Critical Study of the Common Errors Committed by Pupils of Standard IX in Solving Problems in General Mathematics in Some High Schools in Coimbatore.	1965	Madras
286.	Construction and Standardisation of Diagnostic Test in Algebra for Standard X.	1962	Baroda
287.	Construction and Standardisation of Diagnostic Test in Geometry for Standard X.	1962	Baroda
288.	A Critical Study of the Text Books of Mathematics of Standard VIII, IX and in Science of Standard X.	1963	Baroda
289.	Construction and Standardisation of Diagnostic Test in Arithmetic of Standard IX.	1963	Baroda
290.	Construction and Standardisation of Diagnostic Test in Arithmetic of Standard IX.	1963	Baroda
291.	A Study of Concept Formation in Algebra in the Students of Standard IX.	1966	Baroda
292.	A Critical Study of the Text Book in Mathematics in Gujarat State for Std. X.	1966	Baroda
293.	A Study of Concept Formation in Algebra in the Students of Standard VIII.	1966	Baroda
294.	A Comparative Study of Achievements in Language and Arithmetic Among Pupils Coming from the Pre-primary Schools in Akola-Town.	1965	Nagpur
295.	Construction of an Achievement Test in Arithmetic for Class IV of a Primary School.	1966	Nagpur
296.	A Study of the Common Errors in Mathematics as Found in the Elementary Mathematics Paper II of the High School Science Examination, March, 1960.	1963	Osmania
297.	An Investigation into the Teaching of Mathematics in the Secondary Schools of Bihar.	1964	Patna
298.	An Evaluation of the Teaching of Mathematics (Core) at the Higher Secondary Schools of Bihar.	1962	Punjab

S. No.	Title	Year	University
299.	Construction and Standardisation of an Achievement Test in Geometry for IX Class Students.	1963	Punjab
300.	Achievement Test in Arithmetics, Domestic Arithmatic and Household Accounts for the Girl Students of IX Class of the Punjab University (Construction and Standardisation).	1963	Punjab
301.	Evaluation of Curriculum in Mathematics (Core) of the Higher Secondary Examination of the Punjab University in Terms of Objectives.	1964	Punjab
302.	Construction and Standardisation of an Achievement Test in Algebra for Pre-University Class of the Punjab University.	1965	Punjab
303.	Mathematical Competence of the Prospective Elementary School Teachers.	1965	Punjab
304.	An Analytical Study of Mathematics Question Papers of the Middle Standard Examination in the Punjab State to Determine the Relationship Between the Objectives of Teaching Maths. and the Middle Standard Examination.	1964	Punjab
305.	A Critical Study of the Question Papers in Elementary Maths. at the S.S.C. Exam. of the Last Ten Examinations with Reference to Evaluation of Concepts in Mathematics.	1964	Sardar Patel
306.	An Investigation into Sex Difference in Mathematical Ability.	1964	Sardar Patel
307.	Development of Teaching Units in Algebra for Stds. VIII, IX and X.	1965	Sardar Patel
308.	Development of Teaching Units in Arithmatic for Stds. VIII, IX and X.	1965	Sardar Patel
309.	Construction of Achievement Test in Elem. Maths. for Std. VIII.	1966	Sardar Patel
310.	Construction of Achievement Test in Maths. for Std. VIII.	1966	Sardar Patel

S. No.	Title	Year	University
311.	Construction of Achievement Test in Elementary Mathematics of Std. X.	1966	Sardar Patel
312.	Development of Teaching Units in Geometry for Std. VIII, IX and X.	1966	Sardar Patel
313.	Survey of Teaching of Mathematics in the Secondary Schools of Kaira District.	1966	Sardar Patel
314.	Diagnostic Testing in Arithmetic for Class VI of Chhatarpur Town.	1963	Saugar
315.	Construction of Achievement Test in Geometry for Class X of Higher Secondary Schools.	1963	Saugar
316.	A Critical Investigation into the Reasons of High Percentage of Failures in Mathematics in Higher Secondary Classes in District Chhatarpur.	1963	Saugar
317.	Construction of a Battery of Achievement Tests in Mathematics for Class VIII.	1964	Saugar
318.	A Study of the Causes of Failure in Mathematics of the IX Class Students in the Higher Secondary Schools of Madhya Pradesh. (Hindi).	1964	Saugar
319.	Achievement Test in Arithmetic for Children in Std. IV in Gujarati Medium Schools in Bombay City (Gujarati).	1965	SNDT.
320.	Construction of an Achievement Test in Compulsory Mathematics for Class VIII of the City of Cuttack.	1964	Utkal
321.	Construction of an Achievement Test in Mathematics for Secondary Schools and Determination of Local Grade Norms.	1963	Vikram
322.	Construction of an Achievement Test in Algebra and Geometry for Class VII of Secondary Schools of Bhopal City (Hindi).	1964	Vikram
323.	An Analytical Study of the Mistakes in Arithmetic Committed by the Students of Class V in Sehore Tehsil (Hindi).	1965	Vikram

S. No.	Title	Year	University
324.	The Construction of Achievement Test in Core Mathematics for Class X.	1966	Visva Bharti
325.	An Analytical Study of the Mathematical Aptitude of Secondary School pupils in Kerala.	1972	Kerala
326.	The Procedures Adopted and Difficulties Experienced by Pupils of Standard X in Geometrical Constructions.	1970	Kerala
327.	Effect of Intelligence and Anxiety on Mathematics Achievement of Secondary School.	1974	Kerala
328.	A Factor Study of Mental Ability of High and Low Mathematics Achievers.	1972	Kerala
329.	Indentification of Some Personality Variables Which Discriminate Between High Intelligence Normal Achievers and High Inteligence Under Achievers in Mathematics.	1974	Kerala
330.	An Enquiry into the Causes of Under Achievement in Mathematics of the Pupils of Standard VIII in the Schools of Palghat District.	1973	Kerala
331.	Factor Study of a Battery of Mathematical Ability Tests Based on Bloom's Taxonomy–the Cognitive Domain.	1973	Kerala
332.	Comparative Study of Programmed Instruction and Conventional Teaching Techniques as Applied in Teaching Set : Attitude Towards Programmed Instruction.	1972	Rajasthan
333.	Causes of Failures in Mathematics.	1972	Rajasthan
334.	The Problem of Teaching Mathematics in Relation to Life and Pupils' Interests.	1960	Patna
335.	A Survey of Teaching of Mathematics in Secondary Schools with Special Reference to Bombay Province.	1945	Bihar

Appendix—II

List of Studies in Science Education Conducted at the Ph. D. and M. Ed. Levels

S. No.	Title	Year	University
A.	**Science Curriculum**		
1.	Syllabus in General Science for Standards V–VIII and the Visual Aids Needed.	1957	Bombay
2.	Syllabus in General Science from Standard IX to XI and the Visual Aids Needed.	1957	Bombay
3.	Evolution of the Syllabi in Science for the Secondary School in the State of Bombay (VIII–XI).	1958	Bombay
4.	The Place of Elementary Science in Secondary Schools in India.	1951	Delhi
5.	Science Syllabus and its Scope–its Correlation with Children's Interests.	1944	Osmania
6.	A Study of Co-curricular Activities in Natural Science in Some Secondary Schools in the City of Madras.	1958	Madras
7.	The Relation of Extra Curricular Activities with General Science.	1959	Osmania
8.	Study of Curriculum in General Science for Classes VII and VIII.	1951	Allahabad
9.	The Implication of General Science as a School Subject and Suggestions for a Syllabus in General Science for Standards V, VI and VII.	1958	Bombay
10.	An Examination of the Science Curriculum for Junior Classes.	1949	Allahabad
11.	A Tentative Course of Study in General Science for the S.S.C. Examination.	1950	Bombay

S. No.	Title	Year	University
12.	A Critical and Suggestive Study of Science Curriculum of Senior High Schools.	1956	Allahabad
13.	An Examination of the Science Curriculum in Madras Secondary Manual Schools with Suggestions for its Reorganizations.	1959	Madras
14.	Construction of a Syllabus in General Science for the Classes VI and VII of the C.I.E. Experimental Basic School, Delhi.	1958	Delhi
15.	Construction of a new General Science Syllabus for High Schools in Madhya Pradesh in Continuation of and Based upon the New Syllabus in General Science for Middle Schools.	1953	Saugar
16.	A Critical Survey of the Suitability and Working of the New General Science Syllabus in the Punjab.	1954	Osmania
17.	A Study of the Reactions of the Teachers Towards the new General Science Syllabus for Higher Secondary Schools of Punjab.	1960	Punjab
18.	Trends in Science Education.	1961	Mysore
19.	Formulation of Criteria for Preparing the General Science Syllabus for Multipurpose Schools of Delhi.	1962	Delhi
20.	Formulation of a List of General Science Concepts for Classes, VI, VII, and VIII.	1965	Delhi
21.	A Study of Wrong Concept in General Science of the Pupils of Standard VIII.	1963	Gujarat
22.	Formulation of Principles of Reconstruction of a Syllabus in General Science for Schools in Kerala.	1962	Kerala
23.	A Comparative Study of Science Curriculum for Secondary Schools.	1962	Rajasthan
24.	Development of Teaching Units in General Science for Classes VIII, IX and X.	1965	Sardar Patel
25.	Construction of Some Units in General Science for Class IX of Higher Secondary Schools of Madhya Pradesh.	1963	Saugar

S. No.	Title	Year	University
26.	A Study of General Science in Basic Training College.	1963	Vikram
27.	Construction of a Syllabus in General Science for the Classes VI and VII of the CIE Experimental Basic School, Delhi.	1958	Delhi
28.	An Examination of the Science Curriculum for Junior Classes.	1949	Allahabad
29.	Study of Curriculum in General Science for Classes VI and VIII.	1951	Allahabad
30.	An Examination of Science Curriculum in Madras Secondary School with the Suggestion for its Reorganisation (1958).	1947	Madras
31.	Place of Elementary Science in Secondary Schools in India.	1951	Delhi
32.	Syllabus in General Science for Standards V–VIII and the Visual Aids Needed.	1957	Bombay
33.	Syllabus in General Science from Standards IX to XI and the Visual Aids Needed.	1957	Bombay
34.	Study of Organisation of Science Clubs in Delhi as a Curriculum Enrichment Programme	1969	Delhi
35	Critical Analysis of VIII Class General Science Syllabus in Relation to the Expressed Scientific Interests.	1969	Delhi
36.	Correlation in the Teaching History, Geography and Science in Secondary Schools.	1961	Madras
B	**Methods of Teaching Science**		
37.	An experimental study of Lecture, Demonstration, Lecture-cum-Demonstration Methods of Teaching Science.	1961	Allahabad
38.	An Enquiry into the Methods of Teaching Natural Science Through Observation and Experiments.	1957	Madras
39.	The Relative Merits of the Lecture/Demonstration Methods in the Teaching of Science in Schools.	1946	Osmania

S.No.	Title	Year	University
40.	The Relative Educational Values of the Teachers Demonstration Methods and Individual Laboratory Methods in the Teaching of Science in Schools	1942	Osmania
41.	A Critical Examination of Methods of Teaching Natural Science in Some Mysore Secondary Schools.	1959	Madras
42.	Instruction Through Activity.	1952	Baroda
43.	An Investigation to the Effectiveness of the Various Teaching Methods in the Teaching af Chemistry.	1955	Osmania
44.	Construction of a Short Unit Programme of Teaching in Science Based as an Organised Field Trip and Evaluation of its Outcome by Administering an Objective Test.	1954	Delhi
45.	The Relatives Mepits of the Supervised Study vs. the Lecture-Demonstration Methods in the Teaching of Science in Schools (Urdu).	1946	Osmania
46.	The Effectiveness of Programmed Instruction in Physics Experimental Findings.	1969	Aligarh
47.	Comparative Study of Programmed and Conventional Methods of Teaching Physics.	1972	Aligarh
48.	The Value of Mathematics and the Success in the Various Methods of Mathematics Teaching in Indian Schools.	1961	Aligarh
49.	An Enquiry into the Teaching of Science in Higher Secondary and Multipurpose Schools with Particular Refrence to the Teaching of Physics by the Traditional and Problem Solving Methods.	1961	Sri Venkatiswara
50.	Correlation of the Scores in Understanding Physics by Two Different Methods.	1954	Delhi
C.	**Instructional Material in Science**		
51.	A Critical Study of the Aids Used in the Teaching of Natural Science in Forms IV to VI.	1955	Madras
52.	An Experimental study of the Use of Audio Visual Aids in the Teaching of Science in Our Secondary Schools.	1956	Andhra

S. No.	Title	Year	University
53.	The Efficiency of Audio–Visual Aids in the Teaching of Natural Science.	1961	Madras
54.	An Investigation into the Use and Effects of Audio-Visual Aids in the Teaching of General Science.	1955	Osmania
55.	Teaching of Science at the Middle and Primary Stage, with the Help of Inexpensive Improvised Science Apparatus.	1955	Osmania
56.	Aids in the Teaching of Natural Science and Interest of Pupils.	1961	Madras
57.	A Critical Study of Visual Perception and its Relation With the Achievement in Science.	1960	Nagpur
58.	A Critical Study of the Aids Used in Teaching of Physical Science in the Secondary Schools of Kottyam District.	1965	Kerala
59.	The Use of Audio Visual Aids in the Teaching of Science in Standard VIII.	1962	Madras
60.	An Experimental Study of the Use of Audio-Visual Aids in the Teaching of Science in Our Secondary Schools.	1956	Andhra
61.	The Effect of Audio-Visual Aids in the Teaching of Natural Science.	1961	Madras
62.	An Investigation into the Use and Effects of Audio-Visual Aids in the Teaching of General Science in the High School Classes.	1959	Osmania
63.	Audio-Visual Aids in Education.	1950	Allahabad
64.	The Place of Audio-Visual Aids in the Teaching of Selected Secondary School Subjects.	1959	Vikram
65.	A Critical Study of the Aids used in the Teaching of Natural Science in Forms IV to VI.	1955	Madras
66.	A Factual Analysis of Science Concepts as Judged by General Science Text-books for Classes VI, VII and VIII in the States of Delhi, Punjab, Rajasthan and Madhya Pradesh and Critical evaluation of the Same in terms of the Desirable Criteria of Concepts for the Same Classes as Judged by Some Teachers.	1959	Delhi

S. No.	Title	Year	University
67.	A Study of the Concepts in the Text-books of General Science for the Classes VI, VII and VIII of the Punjab.	1958	Punjab
68.	Formulation of Criteria for the Writing and Selection of Textbooks in General Science of the Middle School Standard and Evaluation of a Few General Science Textbooks of Delhi and Punjab States for Middle Standard.	1955	Delhi
69.	A Critical Study of Text-books in Science for Standard X. in use in Gujarati Medium Schools in Bombay.	1961	Bombay
70.	A Critical Study of Tamil Text-books in General Science Based on the Revised Syllabus for High School in Madras.	1948	Madras
71.	A Comparatixe Study of Text-books on General Science for High Schools in Bombay State.	1960	Nagpur
72.	A Survey of the Science Text-books at Secondary Stage.	1957	Osmania
73.	Preparation of Score Card and Formation of Evaluative Criteria for Reviewing Text-books in General Science for Primary Grades.	1963	Anamalai
74.	A Critical Study of the Science Text-books for IX and XI Standards (Madras State).	1964	Anamalai
75.	A Critical Study of the Text-books in General Science for Standard IX	1965	Baroda
76.	A Critical Study of the Text-books in General Science of Standards VIII, IX and X.	1965	Sardar Patel
77.	A Critical Enquiry into the Effectiveness of Text-books in General Science Prevalant in Higher Secondary Schools of Chhatigarh, Devison.	1964	Saugar
78.	A Critical Survey of Text-books in Chemistry with Special Reference to Practical Utility for Higher Secondary School Classes in Madhya Pradesh.	1964	Saugar
79.	A Critical Survey of Text-books Prescribed in General Science for Classes VI, VII and VIII.	1963	Vikram

S. No.	Title	Year	University
80.	A Study of the Concepts in the Text-books of General Science for the Classes VI, VII and VIII of the Punjab.	1958	Punjab
81.	A Survey of the Marathi Science Text-books at Secondary Stage.	1957	Osmania
82.	Evaluation of Physics Text-books in Use in Jalun District of Uttar Pradesh for the High School classes.	1971	Delhi
83.	Critical Study of Tamil Text-book in General Science Based on the Revised Syllabus for High Schools in Madras.	1948	Madras
84.	A Factual Analysis of Science Concepts Judged by General Science Text-books for Class VI, VII and VIII in the States of Delhi, Punjab, Rajasthan and Madhya Pradesh and Critical Evaluation of the Same in Terms of the Desirable Criteria of Concepts for the Same Classes as Judged by Some Teachers.	1959	Delhi
85.	The School Museum and its Role in Teaching of General Science.	1960	Bombay
86.	An Enquiry into the Working of the School Broadcast Programme of the All India Radio in Kerala.	1964	Kerala
87.	The Influence of Film on Children and Adolescents.	1962	Kerala
88.	An Appraisal of the Educational Programmes of Schools Conducted by All India Radio Trivandrum.	1970	Kerala
89.	The Effectiveness of Programmed Instruction in Physics-Experimental Findings.	1969	Aligarh
90.	Comparative Study of programmed and Conventional Methods of Teaching Physics.	1972	Aligarh
91.	Teaching of Science at the Middle and Primary Stages with the Help of Inexpensive Improvised Science Apparatus.	1955	Osmania
D. Evaluation in Science Education			
92.	A Preliminary Study in Attainment of Science in a Group of High School Girls.	1956	Bombay

S. No.	Title	Year	University
93.	An Investigation into the Causes of Failures in General Science in Secondary Schools and their Remedies.	1957	Patna
94.	A Comparative Study of Traditional and Objective Tests in Science.	1959	Aligarh
95.	Construction of a Test for Comparing the Post Basic and Traditional High School Students of Orissa to Apply Facts and Principles of Science in Daily Life.	1961	Utkal
96.	A Critical Study of the Achievement of High School Pupils in Science in Relation to their Achievement in Other Subjects.	1954	Madras
97.	An Analysis of the Attitude of High School Girls Towards Physics and Chemistry and the measure of Correlation Between Attitude and attainment.	1952	Saugar
98.	An Investigation into the Relationship Between the Interests and Achievement in General Science of the Class X Standard Boys of High Schools of Orisssa.	1957	Delhi
99.	A Diagnostic Study of Pupil's Difficulties in the Learning of Certain Topics in Heat & Light in the High School Classes with Suggestions for Remedial Treatment.	1952	Madras
100.	Evaluation of Pupil's Attainment in General Science and General Mathematics Through Dr. Bloom's Technique.	1956	Jabalpur
101.	An Analytical Study of the Test Methods Followed in General Science in Forms IV-VI of Some Madras High Schools with Reference to Their Objectives.	1958	Madras
102.	Planning an Attainment Test in General Science for High School Classes.	1957	Aligarh
103.	Determination of Predictability of Achievement in Higher Secondary Science from the Tests of General Intelligence, Arithmetical Ability and Scientific Aptitude.	1960	Utkal
104.	Analysis of Causes of Mistakes in the Performance of Secondary School Students in Science.	1955	Osmania

S. No.	Title	Year	University
105.	A Diagnostic Study of 500 S.S.L.C. Answer Papers in Elementary Natural Sciences.	1948	Madras
106.	A Diagnostic Study of the Errors of Pupils in Written Examinations in Physical Science.	1949	Madras
107.	A Diagnostic Study of the Common Errors Made by the S.S.L.C. Pupils in General Science in the Public Examination (from 500 answer papers).	1961	Madras
108.	An Enquiry into the Relative Values of Different Types of Tests in Science with Reference to the Madras School Leaving Certificate Examination.	1952	Madras
109.	Evaluation in Teaching of General Science as a Core Subject at the Higher Secondary School Level in Terms of Objectives in Patiala Division (Punjab).	1961	Punjab
110.	Drawbacks of Traditional Examinations, New Type of Examinations and Their Application to the Science Syllabus of Osmania Matriculation.	1941	Osmania
111.	The Construction of a Test of Understanding of the Scientific Principles and Their Applications in Daily Life for the Students of Delta Class in Delhi Higher Secondary Schools.	1958	Delhi
112	Construction of a Scientific Aptitude Test for the Pupils (of Class IX) of High Schools and Higher Secondary Schools in Orissa.	1959	Utkal
113.	Construction of Achievement Tests in General Science Standard VIII in English Medium Schools in Bombay City.	1966	Bombay
114.	Construction of Achievement Tests in General Science Standard VIII in English Medium Schools in Bombay City.	1966	Bombay
115.	Preparation of a Predictive Battery of Tests for Science for Boys of Secondary Schools.	1966	Nagpur
116.	Construction and Standardization of Scientific Aptitude Test.	1964	S. Patel

S. No.	Title	Year	University
117.	A Factorial Study of the Intermediate Examination Marks of Science Students.	1963	Agra
118.	An Enquiry into the Problems in the Teaching of Biology by the Biology Teachers of IX and X Classes in the Higher Secondary Schools of Meerut.	1963	Agra
119.	Prediction of Prospective Success Regarding Attainment of Marks in Science in High Schools Examination.	1965	Agra
120.	Construction of an Attitude Test in Biological Science for Classes IX to XII.	1964	Andhra
121.	Construction of An Objective Type of Achievement Test in General Science for IX Class.	1964	Andhra
122.	Construction of Standardised Objective Test to Measure the Ability of Cause and Relationship in General Science of Pupils of Classes IX to XI.	1964	Andhra
123.	Construction of a Diagnostic Test in General Science for Pupils of Class X in the High Schools of Cuttack City.	1962	Utkal
124.	Construction of an Achievement Test in General Science for Class III of the Primary Schools of Cuttack City.	1962	Utkal
125.	Construction of an Achievement Test of General Science for Class VIII Pupils of Tripura Schools.	1964	Delhi
126.	Construction of an Achievement Test in General Science for Class VIII Students of Tripura Schools	1964	Delhi
127.	Diagnostic Tests in General Science for Standard VIII.	1962	Gujarat
128.	The Construction and Standardization of an Achivement Test in General Science for Standard VIII.	1963	Gujarat
129.	To Construct an Achievement Test in Chemistry for High School Classes.	1964	Gorakhpur
130.	Achievement Test in General Science for Junior High School Classes.	1964	Gorakhpur

S. No.	Title	Year	University
131.	Diagnastic Test in General Science for Standard IX.	1965	Gujarat
132.	Construction and Standardisation of an Achievement Test in General Science for Standard VIII.	1966	Gujarat
133.	A Construction and Standardisation of an Achievement Test in General Science for the Pupils Studying in Standard VI of the Secondary Schools.	1966	Gujarat
134.	Preparation of an Achievement Test in Chemistry for Class IX in Higher Secondary Schools (based on Dr. Blooms Technique).	1963	Jabalpure
135.	Construction of an Achievement Test in General Science for Delta Class (VIII Grade) Students of Delhi Schools in Hindi as Their Medium of Instruction.	1965	Jamia Millia
136.	Construction of an Achievement Test in General Science for Standard X.	1962	Kerala
137.	Construction of an Objective Type Achievement Test in General Science for X Class Students of Secondary Schools of Punjab.	1964	Kurukshetra
138.	A Comparative Study of the Achievement in General Science of Urban and Rural Students Reading in Standard X in the High Schools in Coimbatore District.	1964	Madras
139.	Construction and Standardization of Diagonostic Test in Science of Standard X.	1963	Baroda
140.	Construction and Administration of Objective Centred Test in General Science for Standard VIII and Summarization of Results.	1966	Baroda
141.	Construction and Standardization of General Science Tests for Class VII	1963	Osmania
142.	Construction of Achievement Tests in Physics for Class X (Special) of Higher Secondary Schools of Patna.	1963	Patna
143.	Construction and Standardization of Objectives Tests in Everyday Science for Class IX.	1963	Patna

S. No.	Title	Year	University
144.	Evaluation of Achievement in Science Teaching in Secondary Schools of Bihar.	1964	Patna
145.	A Comparative Study of the Results of Students Offering Science in Higher Secondary Schools of Bihar and Pre-University Examination of Patna University.	1964	Patna
146.	Construction and Standardization of the Test in Teaching of Biology as One of the Elective Subjects at Higher Secondary and Pre-university Level in the Terms of Objective and Expected Behaviour Pattern.	1964	Punjab
147.	Test Construction in General Science (VIII class).	1964	Rajasthan
148.	An Investigation into the Vocational Preferences and other Related Factors of the Superior Achievevers in Science of Class IX in Rajasthan.	1965	Rajasthan
149.	Construction of an Achievement Test in General Science for Class VIII.	1963	Sagar
150.	Achievement Test in General Science for Class VII.	1963	Sagar
151.	A Comparative Study of Achievement in Science of Middle School Students of Urban and Rural Areas in Satna District.	1962	Utkal
152.	Construction of Diagnostic Test in General Science for Pupils of Class X in the High Schools of Cuttack City.	1962	Utkal
153.	Construction of an Achievement Test in General Science for Class III of the Primary Schools of Cuttack City.	1966	Utkal
154.	Construction of an Achievement Test in General Science for Class VIII of Secondary Schools in District of Bisthum.	1964	Visva Bharati
155.	Construction and Standardization of an Attainment Test in General Science for Class VIII of U. P. Schools.	1960	Banaras
156.	Construction and Standardization of Achievement Test in General Science in Gujarati (Standard IX and X).	1960	Baroda

S. No.	Title	Year	University
157.	Construction and Standardisation of Achievement Tests in General Science (Physics and Chemistry).	1958	Mysore
158.	Construction, Administration and Standardization of an Achievement Test in General Science.	1961	Mysore
159.	General Science Test for Class VI.	1950	Allahabad
160.	Domestic Science Test for Class X.	1950	Allahabad
161.	General Science Test for Class X.	1951	Allahabad
162.	General Science Test for Class VIII.	1951	Allahabad
163.	An Attainment Test in General Science (Biology) for Class VIII.	1955	Allahabad
164.	Construction of an Achievement Test in General Science for VI Form Students.	1956	Andhra Pradesh
165.	Achievement tests in General Science for Students in Standard X in Gujarati Medium Schools in Bombay.	1960	Bombay
166.	Construction of An Objective Test in General Science for Students Appearing at the High School Certificate Examination in Orissa.	1957	Delhi
167.	Construction of an Objective Test in Science to Measure the Understanding Cause and Effect Relationship for the Students Appearing at the High School Examination of Board of High School and Intermediate Education (U. P.)	1958	Delhi
168.	Construction of An Objective Type Achievement Test in General Science for Class VIII Students of Delhi.	1959	Delhi
169.	Achievement Tests in General Science in Standards IX and X (Form IV and V).	1959	Kerala
170.	An Achievement Test in General Science for Junior High School Classes.	1955	Lucknow
171.	Achievement Test in General Science for Junior High School Classes.	1956	Lucknow

S. No.	Title	Year	University
172.	Construction and Standardisation of Achievement Tests in Science for Standard VIII.	1957	Baroda
173.	Achievement Test in General Science for Standard VIII-Construction and Standardisation.	1959	Baroda
174.	Construction of an Achievement Test in General Science for Class VII of a Senior Basic School.	1961	Nagpur
175.	Standardisation of Science Tests for Secondary School (Urdu)	1947	Osmania
176.	Construction and Standardisation of Achievement Tests in General Science for Class IX.	1957	Osmania
177.	Construction and Standardisation of an Achievement Test in General Science for the Class IX (Multipurpose section).	1960	Osmania
178.	Construction and Standardization of an Objective Type Achievement Test in General Science for Class VIII Students of the Punjab University.	1958	Osmania
179.	Construction and Standardisation of an Achievement Test in General Science for Class VII Students in Punjab.	1960	Punjab
180.	Construction of an Achievement Test in General Science for Class VIII.	1956	Rajasthan
181.	The Construction of New Type Achievement Test in General Science for Class V.	1953	Sagar
182.	The Construction of New Type Achievement Test in General Science for Class VI.	1954	Sagar
183.	The Construction of New Achievement Test in General Science for Class VII.	1955	Sagar
184.	Construction of An Achievement Test in General Science for Class VIII.	1957	Sagar
185.	Construction of An Achievement Test in General Science for the High School Pupils of Orissa.	1958	Utkal
186.	Construction of an Achievement Test in General Science for Class VIII	1958	Vikram

S No.	Title	Year	University
187.	Construction of an Achievement Test in General Science for Class VII.	1959	Vikram
188.	Construction of an Achievement Test tn General Science for Class III.	1961	Vikram
189.	A Preliminary Study in Attainment of Science in a Group of High School Girls.	1956	Bombay
190.	Analysis of Variance of Scholastic Attainment in the Branches of Science and Mathematics at the High Scool Level.	1969	Gorakhpur
191.	A Critical Study of the Achievement of High School Pupils in Science in Relation to their Achievement in Other Subjects.	1954	Madras
192.	Construction of New Type Achievement Test in Mathematics for Class VIII.	1957	Sagar
193.	Evaluation of the Achievement in General Science of the Students of Classes IX & X.	1960	Agra
194.	Evaluation of Pupils Attainment in General Science and General Mathematics Through Dr. Bloom's Technique.	1959	Jabalpur
195.	A Study of the Effect of Science Clubs on Attainment and Attitude Towards Science.	1959	Jabalpur
196.	Determination of Predictability of Achievement in Higher Secondary Science from the Tests of General Intelligence, Arithmetical Ability and Scientific Aptitude.	1960	Utkal
197.	A Critical Study of Visual Perception and its Relation with the Achievement in Science.	1960	Nagpur
198.	Evaluation in Activity-Centred Schools of Bihar.	1960	Patna
199.	An Analytical Study of the Test Methods Followed in General Science in Forms IV-VI of Some Madras High Schools with Reference to Their Objectives.	1958	Madras
200.	Construction and Standardization of an Achievement Test in Biology for High School Classes.	1960	Agra

S. No.	Title	Year	University
201.	Achievement Test in Biology for Intermediate Classes.	1959	Lucknow
202.	Achievement Test in Biology for Class X.	1961	Lucknow
203.	Achievement Test Construction for Class IX in Biology.	1957	Patna
204.	Construction of an Objective Test in Chemistry for the High School Students in Orissa and Comparison of its Norms with that of a Test in Physics.	1957	Patna
205.	Construction of an Achievement Test in Chemistry for High School Classes.	1960	Aligarh
206.	Construction and Standardization of Achievement Test in Chemistry for High School Pass Students.	1957	Allahabad
207.	Measurement of Achievement in Chemistry : Construction of an Achievement Test in Chemistry for the Class X Stage of Delhi Higher Secondary Schools.	1954	Delhi
208.	Construction of an Achievement Test in Chemistry for High School Classes.	1957	Lucknow
209.	Achievement Test in Chemistry for High School Classes.	1961	Lucknow
210.	An Achievement Test in Chemistry for Intermediate Classes.	1961	Lucknow
211.	Preparation of an Achievement Test in Chemistry for Class X.	1959	Nagpur
212.	Construction and Standardization of an Achievement Test in Chemistry for the High School Classes of the Punjab University.	1957	Osmania
213.	A Diagnostic Study of 500 S. S. L. C. Answer Papers in Elementry Natural Science.	1948	Madras
214.	Construction of New Type Achievement Test in Chemistry for Class IX.	1961	Sagar
215.	Determination of the Suitability of the Achievement Test in Physics for High School Classes Prepared by the Author for the Students of Gorakhpur.	1965	Lucknow

S. No.	Title	Year	University
216.	Construction of an Achievement Test in Geometry for the Students of Class VIII in High Schools of Calcutta.	1954	Delhi
217.	An Attainment Test in Physics for Class X.	1954	Allahabad
218.	Measurement of Achievement Test in Physics : Construction of an Achievement Test in Physics Mechanics for the Class X Pupils of Delhi High Schools.	1956	Delhi
219.	Construction of an Achievement Test in Physics for High School Classes.	1959	Gorakhpur
220.	The Construction and Standardization of an Attainment Test in Physics for Grade X.	1958	Gujarat
221.	The Construction and Standardization of an Attainment Test in Physics for Grade VIII.	1959	Gujarat
222	Construction of an Attainment Test in Physics for Classes IX through Dr. Bloom's Technique.	1960	Jabalpur
223.	Standardization of an Achievement Test in Physics for High School Classes.	1961	Lucknow
224.	Standardization of a Test in High School Physics.	1953	Patna
225.	Construction of an Objective Achievement Test in Mechanics (a part of Physics) for Class X.	1956	Patna
226.	Preparation of an Achievement Test in Physics for Class X in Patna.	1957	Patna
227.	Construction of New Type Achievement Test in Physics for Class IX.	1960	Sagar
228,	Evaluation in Teaching of General Science as a Core Subject at the Higher Secondary School Level in Terms of Objectives in Patiala Division.	1961	Punjab
229.	Construction and Standardization of Achievement Test in Chemistry for H. S. Pass Students	1957	Allahabad
230.	Achievement and Under Achievement in Science and Some of its Correlates.	1957	Delhi

S. No.	Title	Year	University
231.	Construction of a Diagnostic Test in Physiolgical Biology (UNESCO Project) for Classes VI of the Govt. Higher Secondary Schools of Delhi State.	1970	Delhi
232.	Investigation into the Understanding of Some Concepts in Chemistry for Secondary School Pupils in Order to Provide Subject Guidance.	1971	Delhi
233.	An Essay in Construction and Standardisation of Achievement Test in General Science for New Class VIII.	1959	Osmania
234.	Construction and Standardization of an Achievement Test in General Science for Class IX (multipurpose section.)	1960	Osmania
235.	Construction and Standardizatian of an objective Type Achievement Test in General Science for Class VIII Students of the Punjab University.	1958	Osmania
236.	Construction and Standardization of an Observation Test for the age of 13 plus.	1957	Osmania
237.	The Construction and Standardization of a Reasoning Test : A Group Test in Gujarat for Secondary School Children.	1956	Gujarat
238.	Construction of an Achievement Tess in Botany for High School Classes of Orrisa.	1957	Patna
239.	Construction of Achievement in Arithmetic for High School Classes and Study of Relationship Between General Intelligence and Achievement in Arithmetic.	1957	Aligarh
240.	Construction of an Achievement Test in Chemistry for Higher Secondary Class and Study of Relationship Between Achievement in Chemistry and General Intelligence of Boys and Girls of Higher Secondary Class.	1968	Aligarh
241.	Construction of an Aehievement Test in General Science for High School Classes.	1972	Aligarh
242.	Construction of Diagnostic Test in Geometry for Class VIII students in Aligarh City.	1972	Aligarh

S. No.	Title	Year	University
243.	Coustruction of an Achievement Test in Biology for Class IX in U. P.	1972	Aligarh
244.	An Evaluation of Science Practical Work at the Higher Secondary Stage in Vidhya Pradesh Region of Madhya Pradesh.	1961	Rewa
245.	Preparation of an Achievement Test in Arithmetic for Class VIII.	1961	Rewa
246.	Construction of an Achievement Test in Chemistry for Class IX.	1961	Rewa
247.	Longitudinal Study of Fluctuations in Pupil Performance in Science at Home Examinations.	161	Rewa
248.	Problems Facing General Science Teachers in Secondary Schools-Standard (VIII-IX) in Teaching the New Syllabus in the English Medium Schools in Bombay City.	1959	Bombay
249.	An Investigation Into the Pre-service Professional Preparation of Science Teachers for Secondary Schools in India.	1962	Bombay
250.	The Role of Science Consultants Service in Delhi Schools.	1966	Delhi
251.	A study of Problems Related to the Preparation General Science Teachers in Delhi State.	1966	Jamia Milia
252.	An Evaluation of Objectives, Course and the Teaching of Science Teachers in Higher Secondary Schools of Lucknow.	1964	Lucknow
253.	The Problem of Shortage of Science Teachers in Bihar.	1963	Patna
254.	A Study of the Reaction of the Teachers Towards the New General Science Syllabus for Higher Secondary Schools of Punjab.	1960	Punjab
255.	An Investigation into the Attitudes of Teachers Towards In-service Training.	1960	Rajasthan
256.	Measurement of Attitutes of Secondary Teachers and Principals Towards Extension Services.	1960	Baroda

S. No.	Title	Year	University
257.	An Investigation into the Pre-service Professional Preparation of Science Teachers for Secondary Schools in India.	1959	Delhi
258.	Reactions of Secondary School Principals and Teachers (in Delhi) Towards Activities of Inservice Education Programmes.	1967	Delhi
259.	Investigation into the Problems Faced by Teachers Teaching Physics to Students of Class VI in Delhi School Under the UNESCO Science project.	1968	Delhi
260.	Investigation into the Areas in Which Teachers Need In-service Training.	1968	Delhi
261.	A Critical Study of Science Teaching in Girls Schools in Greater Bombay with Special Reference to Teachers View Point and Requirements of New Syllabus.	1958	Bombay
262.	An Investigatigation into the Problems of Science Teacher in the Primary Schools Of Orissa.	1966	Utkal
263.	A Study of the Influence of the Philosophy of Science on the Class Room Teaching of Science in Secondary School.	1956	Osmania

APPENDIX – III

List of Participants

(A) Workshop held at Trivandrum

1. Dr. N. Vedmani Manuel,
   Head and Professor of Education,
   Kerala University,
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2. K. Kumaraswami Pillai,
   Professor of Education,
   Annamatar University,
   Annamatar Nagar, Tamil Nadu.
3. Dr. R. Srinivasa Rao,
   Head, Deptt. of Education,
   Sri Venkateswar University,
   Tripura, (A.P.)
4. Shri B C. Patil.
   University College of Education,
   Dharwar.
5. Dr. V. V. Chacko,
   Nirmala Institute of Education,
   Altinho, Panaji, Goa.
6. Miss Pushpita John,
   Reader,
   Department of Education,
   Kerala University, Kerala.

7. Smt. N. S. Amma,
Principal,
N. S. S. Training College,
Pandalam, Kerala.

8. Dr. C. A. Abraham,
Peet Memorial Training College,
Mavelikkara, Kerala.

9. Dr. A Sukumaran Nair,
Department of Education,
Kerala University, Kerala.

10. Dr. K. Sadasivan Pillai,
Deptt. of Education,
Kerala University, Kerala.

11. Dr. N. P. Gopalan,
S. N. Training College,
Nedugavda, Kerala.

12. Mr. R. J. Roshiah,
Professor,
Meston Training College,
Royapeth, Madras.

13. Mr. C. V. Venkatachalam,
Asstt. Professor for Biological Sciences,
Teachers' College,
Saidapet, Madras.

14, Mr. T. K. D. Nair,
Co-ordinatnr (Primary Education)
State Institute of Education, Poojappura,
Trivandrum-12.

NCERT CONSULTANTS

1. Shri V. N. Wanchoo,
   Reader, Deptt. of Education in Science
   and Mathematics, NCERT, New Delhi.

2. Shri H. L. Sharma,
   Lecturer,
   Deptt. of Education in Science and
   Mathematics, NCERT, New Delhi.

3. Dr. M. Haridas,
   Field Advisor,
   NCERT, Trivandrum-12.

(B) Workshop held at Amritsar

1. Dr. J. N. Joshi,
   Reader in Education,
   Punjab University,
   Chandigarh.

2. Dr. D. R. Vij,
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3. Dr. R. N. Mahrotra,
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   C. I. E., Delhi.

4. Dr. S. P. Duggal,
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5. Dr. A. B. Phatak,
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6. Dr. R. P. Singh,
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   Patna-4.

7. Shri H. N. Mujoo,
   Education Deptt.,
   Lucknow University,
   Lucknow.

8. Dr. (Miss) R. Kaur
   State Institute of Science Education,
   Chandigarh.

9. Shri W. P. Kurchania,
Director, State Institute of
Science Education,
Jabalpur (M. P.)

10. Dr. R. C. Deva,
Deptt of Education,
Aligarh Muslim University,
Aligarh (U. P.)

11. Dr. Atam Prakash,
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Allahabad. (U. P.)

12. Shri R. K. Mohta,
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13. Dr. V. K. Kohli,
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14. Dr. J. K. Sood,
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15. Prof. Rajinder Singh Uppal
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16. Shri Kapildev Bhatia,
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17. Shri R. K. Kapoor,
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18. Dipty Ghosal
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1. Dr. Rais Ahmed,
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2. Prof. V. N Wanchoo,
Principal, RCE,
Ajmer.

3. Shri Man Mohan Singh Arora
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NCERT, New Delhi.

4. Dr. A. N. Bose,
Head, DESM,
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5 Shri Pritam Singh,
Reader, NCERT,
New Delhi.

6. Shri H. L. Sharma,
Lecturer, NCERT,
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